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Ko et al.

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(45) **Date of Patent: *Jul. 28, 2015**

(54) **APPARATUS FOR TRANSMITTING AND RECEIVING A SIGNAL AND METHOD OF TRANSMITTING AND RECEIVING A SIGNAL**

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This patent is subject to a terminal disclaimer.

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Related U.S. Application Data

(63) Continuation of application No. 13/941,159, filed on Jul. 12, 2013, now Pat. No. 8,750,398, which is a continuation of application No. 12/922,682, filed as application No. PCT/KR2009/002505 on May 12, 2009, now Pat. No. 8,503,550.

(60) Provisional application No. 61/112,158, filed on Nov. 6, 2008.

(51) **Int. Cl.**

H04L 27/34	(2006.01)
H04L 5/00	(2006.01)
H04L 27/26	(2006.01)

(52) **U.S. Cl.**

CPC ***H04L 27/34*** (2013.01); ***H04L 5/0007*** (2013.01); ***H04L 5/0053*** (2013.01); ***H04L 27/2607*** (2013.01)

(58) **Field of Classification Search**

CPC H04L 27/2607; H04L 27/2608; H04L 27/2602; H04L 5/0007; H04L 5/0053; H04L 5/0044; H04L 5/023; H04L 2025/30414; H04L 27/34

See application file for complete search history.

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(57) **ABSTRACT**

The present invention relates to a method of transmitting and receiving signals and a corresponding apparatus. One aspect of the present invention relates to a method of receiving a signal, which includes interleaving in an appropriate manner for a channel bonding system. The interleaving can allow decoding a user requested service at a random tuner window position.

8 Claims, 56 Drawing Sheets

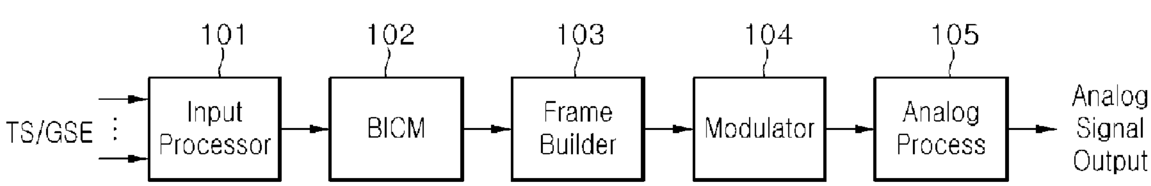

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Fig. 1

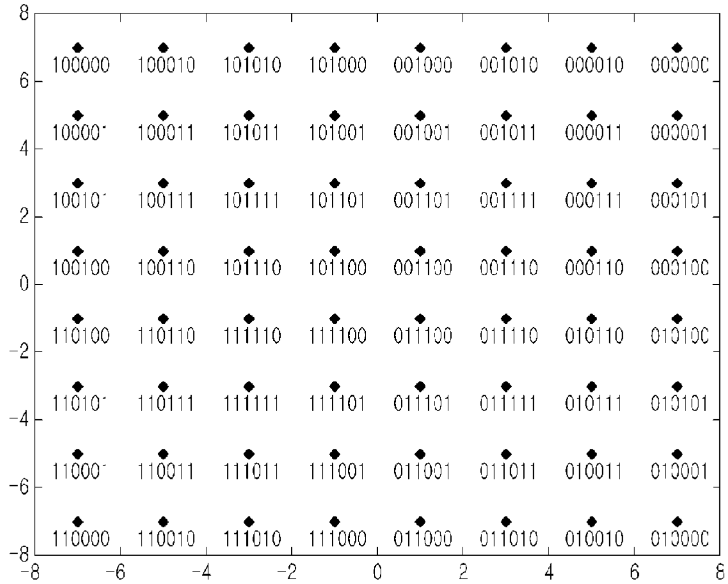


Fig. 2

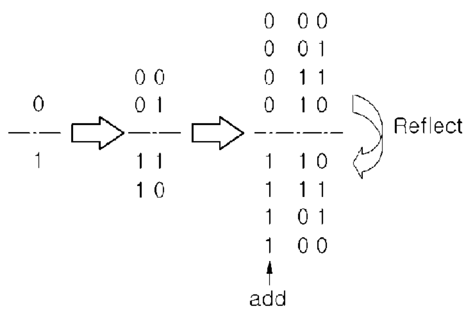


Fig. 3

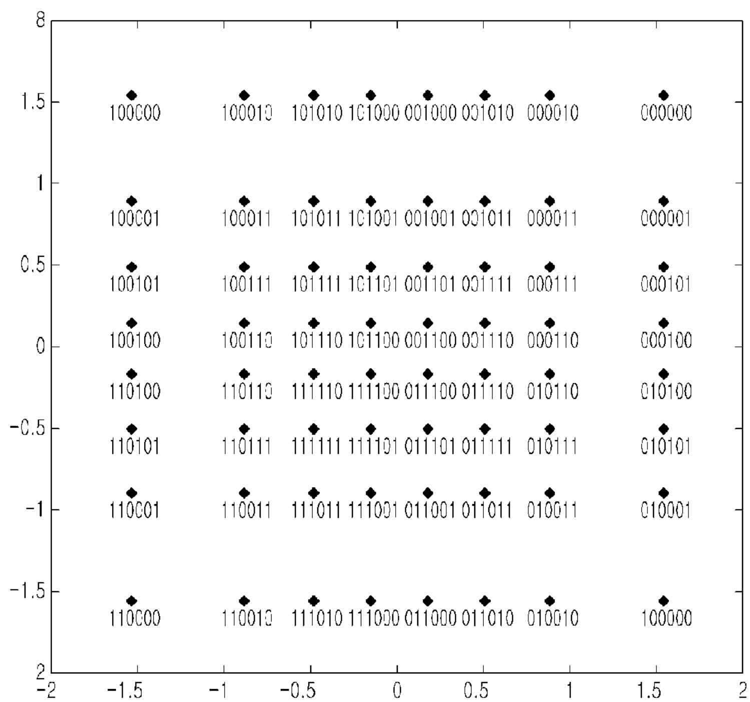


Fig. 4

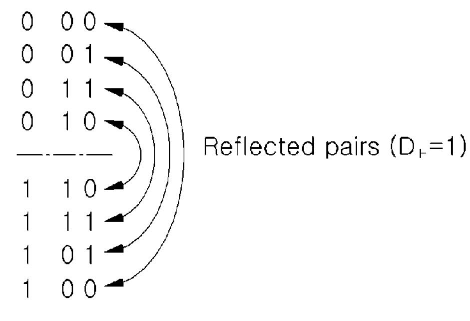

0 00
0 01
0 11
0 10
1 10
1 11
1 01
1 00
Reflected pairs (D_H=1)
Different bit

Fig. 5

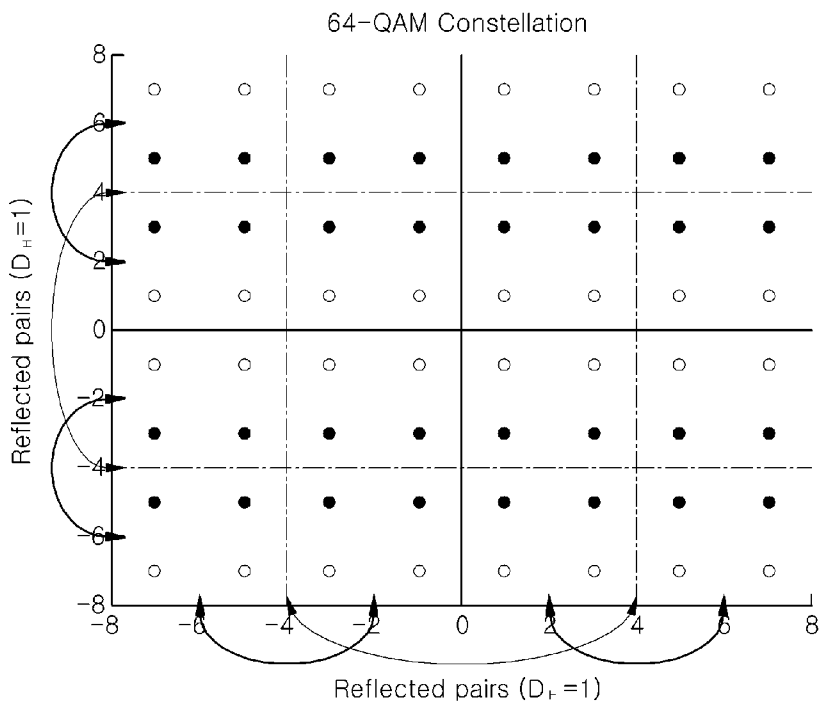
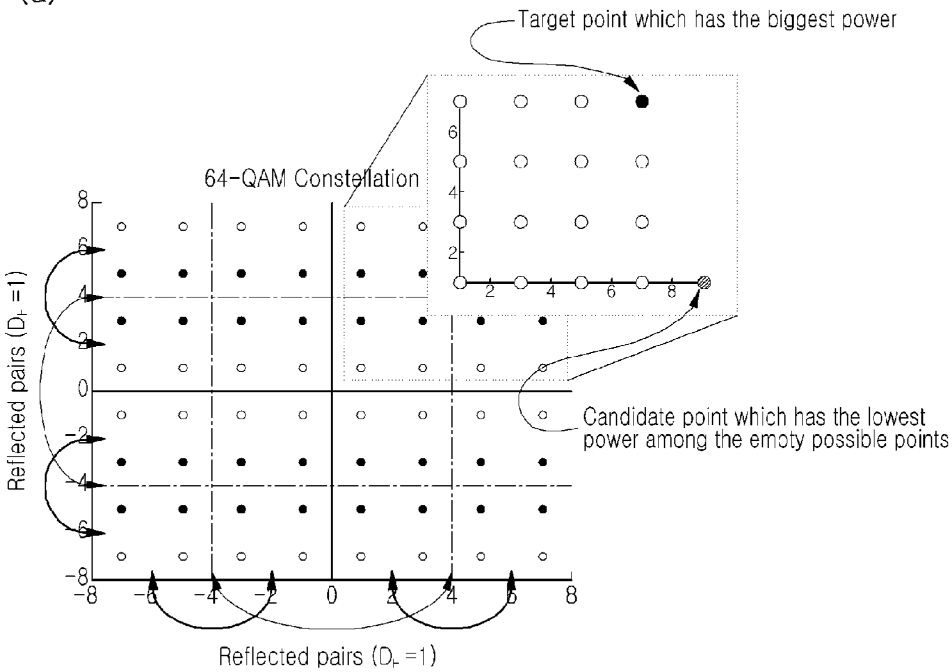

64-QAM Constellation
8
6
4
2
0
-2
-4
-6
-8
-8
-6
-4
-2
0
2
4
6
8
Reflected pairs (D_H=1)
Reflected pairs (D_H =1)

Fig. 6

(a)


Target point which has the biggest power
64-QAM Constellation
Candidate point which has the lowest power among the emoty possible points
Reflected pairs (D_F =1)
Reflected pairs (D_F =1)

(b)

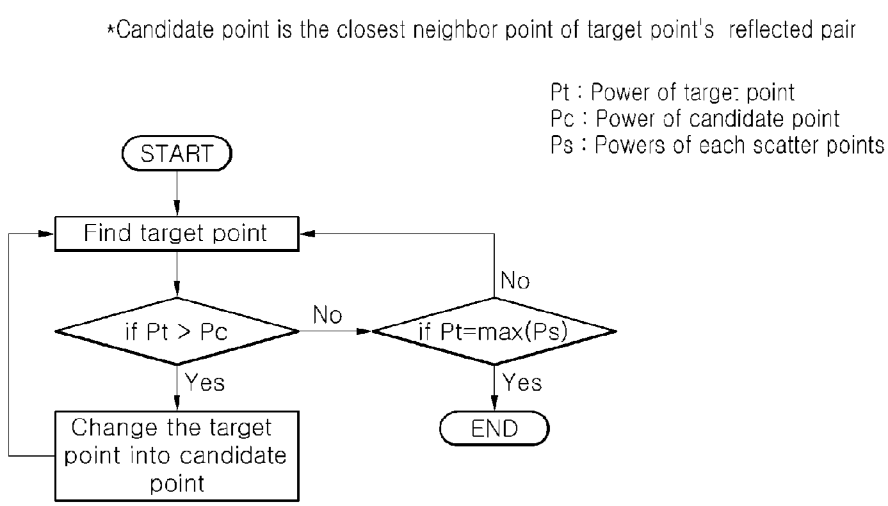

*Candidate point is the closest neighbor point of target point's reflected pair
Pt : Power of targe: point
Pc : Power of candidate point
Ps : Powers of each scatter points
START
Find target point
if Pt > Pc
No
if Pt=max(Ps)
No
Yes
Change the target point into candidate point
Yes
END

Fig. 7

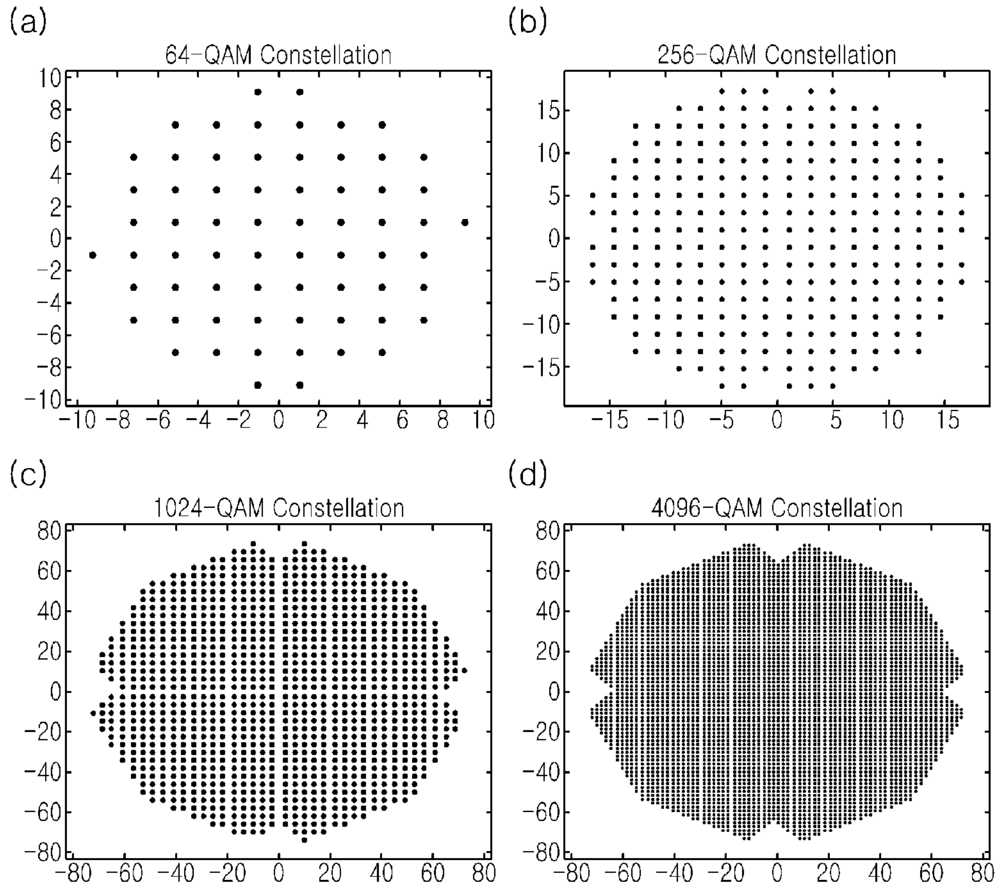

(a)
64-QAM Constellation
(b)
256-QAM Constellation
(c)
1024-QAM Constellation
(d)
4096-QAM Constellation

FIG. 8

Value	Scatter
0	9 + 1i
1	7 + 5i
2	5 + 7i
3	5 + 5i
4	7 + 1i
5	7 + 3i
6	5 + 1i
7	5 + 3i
8	1 + 7i
9	1 + 5i
10	3 + 7i
11	3 + 5i
12	1 + 1i
13	1 + 3i
14	3 + 1i
15	3 + 3i
16	1 - 9i
17	7 - 5i
18	5 - 7i
19	5 - 5i
20	7 - 1i
21	7 - 3i
22	5 - 1i
23	5 - 3i
24	1 - 7i
25	1 - 5i
26	3 - 7i
27	3 - 5i
28	1 - 1i
29	1 - 3i
30	3 - 1i

FIG. 9

31	3 - 3i
32	-1 + 9i
33	-7 + 5i
34	-5 + 7i
35	-5 + 5i
36	-7 + 1i
37	-7 + 3i
38	-5 + 1i
39	-5 + 3i
40	-1 + 7i
41	-1 + 5i
42	-3 + 7i
43	-3 + 5i
44	-1 + 1i
45	-1 + 3i
46	-3 + 1i
47	-3 + 3i
48	-9 - 1i
49	-7 - 5i
50	-5 - 7i
51	-5 - 5i
52	-7 - 1i
53	-7 - 3i
54	-5 - 1i
55	-5 - 3i
56	-1 - 7i
57	-1 - 5i
58	-3 - 7i
59	-3 - 5i
60	-1 - 1i
61	-1 - 3i
62	-3 - 1i
63	-3 - 3i

FIG. 10

Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter
0	17 + 1i	64	1 - 17i	128	-1 + 17i	192	-17 - 1i
1	17 + 3i	65	17 - 3i	129	-17 + 3i	193	-17 - 3i
2	3 + 17i	66	3 - 17i	130	-3 + 17i	194	-3 - 17i
3	13 + 13i	67	13 - 13i	131	-13 + 13i	195	-13 - 13i
4	15 + 9i	68	15 - 9i	132	-15 + 9i	196	-15 - 9i
5	17 + 5i	69	17 - 5i	133	-17 + 5i	197	-17 - 5i
6	13 + 9i	70	13 - 9i	134	-13 + 9i	198	-13 - 9i
7	13 + 11i	71	13 - 11i	135	-13 + 11i	199	-13 - 11i
8	9 + 15i	72	9 - 15i	136	-9 + 15i	200	-9 - 15i
9	9 + 13i	73	9 - 13i	137	-9 + 13i	201	-9 - 13i
10	5 + 17i	74	5 - 17i	138	-5 + 17i	202	-5 - 17i
11	11 + 13i	75	11 - 13i	139	-11 + 13i	203	-11 - 13i
12	9 + 9i	76	9 - 9i	140	-9 + 9i	204	-9 - 9i
13	9 + 11i	77	9 - 11i	141	-9 + 11i	205	-9 - 11i
14	11 + 9i	78	11 - 9i	142	-11 + 9i	206	-11 - 9i
15	11 + 11i	79	11 - 11i	143	-11 + 11i	207	-11 - 11i
16	15 + 1i	80	15 - 1i	144	-15 + 1i	208	-15 - 1i
17	15 + 3i	81	15 - 3i	145	-15 + 3i	209	-15 - 3i
18	13 + 1i	82	13 - 1i	146	-13 + 1i	210	-13 - 1i
19	13 + 3i	83	13 - 3i	147	-13 + 3i	211	-13 - 3i
20	15 + 7i	84	15 - 7i	148	-15 + 7i	212	-15 - 7i
21	15 + 5i	85	15 - 5i	149	-15 + 5i	213	-15 - 5i
22	13 + 7i	86	13 - 7i	150	-13 + 7i	214	-13 - 7i
23	13 + 5i	87	13 - 5i	151	-13 + 5i	215	-13 - 5i
24	9 + 1i	88	9 - 1i	152	-9 + 1i	216	-9 - 1i
25	9 + 3i	89	9 - 3i	153	-9 + 3i	217	-9 - 3i
26	11 + 1i	90	11 - 1i	154	-11 + 1i	218	-11 - 1i
27	11 + 3i	91	11 - 3i	155	-11 + 3i	219	-11 - 3i
28	9 + 7i	92	9 - 7i	156	-9 + 7i	220	-9 - 7i
29	9 + 5i	93	9 - 5i	157	-9 + 5i	221	-9 - 5i
30	11 + 7i	94	11 - 7i	158	-11 + 7i	222	-11 - 7i

FIG. 11

31	11 + 5i	95	11 - 5i	159	-11 + 5i	223	-11 - 5i
32	1 + 15i	96	1 - 15i	160	-1 + 15i	224	-1 - 15i
33	1 + 13i	97	1 - 13i	161	-1 + 13i	225	-1 - 13i
34	3 + 15i	98	3 - 15i	162	-3 + 15i	226	-3 - 15i
35	3 + 13i	99	3 - 13i	163	-3 + 13i	227	-3 - 13i
36	1 + 9i	100	1 - 9i	164	-1 + 9i	228	-1 - 9i
37	1 + 11i	101	1 - 11i	165	-1 + 11i	229	-1 - 11i
38	3 + 9i	102	3 - 9i	166	-3 + 9i	230	-3 - 9i
39	3 + 11i	103	3 - 11i	167	-3 + 11i	231	-3 - 11i
40	7 + 15i	104	7 - 15i	168	-7 + 15i	232	-7 - 15i
41	7 + 13i	105	7 - 13i	169	-7 + 13i	233	-7 - 13i
42	5 + 15i	106	5 - 15i	170	-5 + 15i	234	-5 - 15i
43	5 + 13i	107	5 - 13i	171	-5 + 13i	235	-5 - 13i
44	7 + 9i	108	7 - 9i	172	-7 + 9i	236	-7 - 9i
45	7 + 11i	109	7 - 11i	173	-7 + 11i	237	-7 - 11i
46	5 + 9i	110	5 - 9i	174	-5 + 9i	238	-5 - 9i
47	5 + 11i	111	5 - 11i	175	-5 + 11i	239	-5 - 11i
48	1 + 1i	112	1 - 1i	176	-1 + 1i	240	-1 - 1i
49	1 + 3i	113	1 - 3i	177	-1 + 3i	241	-1 - 3i
50	3 + 1i	114	3 - 1i	178	-3 + 1i	242	-3 - 1i
51	3 + 3i	115	3 - 3i	179	-3 + 3i	243	-3 - 3i
52	1 + 7i	116	1 - 7i	180	-1 + 7i	244	-1 - 7i
53	1 + 5i	117	1 - 5i	181	-1 + 5i	245	-1 - 5i
54	3 + 7i	118	3 - 7i	182	-3 + 7i	246	-3 - 7i
55	3 + 5i	119	3 - 5i	183	-3 + 5i	247	-3 - 5i
56	7 + 1i	120	7 - 1i	184	-7 + 1i	248	-7 - 1i
57	7 + 3i	121	7 - 3i	185	-7 + 3i	249	-7 - 3i
58	5 + 1i	122	5 - 1i	186	-5 + 1i	250	-5 - 1i
59	5 + 3i	123	5 - 3i	187	-5 + 3i	251	-5 - 3i
60	7 + 7i	124	7 - 7i	188	-7 + 7i	252	-7 - 7i
61	7 + 5i	125	7 - 5i	189	-7 + 5i	253	-7 - 5i
62	5 + 7i	126	5 - 7i	190	-5 + 7i	254	-5 - 7i
63	5 + 5i	127	5 - 5i	191	-5 + 5i	255	-5 - 5i

FIG. 12

Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter
0	33 + 1i	64	31 + 1i	128	1 + 31i	192	1 + 1i	256	1 - 33i	320	31 - 1i	384	1 - 31i	448	1 - 1i
1	33 + 3i	65	31 + 3i	129	1 + 29i	193	1 + 3i	257	33 - 3i	321	31 - 3i	385	1 - 29i	449	1 - 3i
2	3 + 33i	66	29 + 1i	130	3 + 31i	194	3 + 1i	258	3 - 33i	322	29 - 1i	386	3 - 31i	450	3 - 1i
3	35 + 3i	67	29 + 3i	131	3 + 29i	195	3 + 3i	259	3 - 35i	323	29 - 3i	387	3 - 29i	451	3 - 3i
4	33 + 7i	68	31 + 7i	132	1 + 25i	196	1 + 7i	260	33 - 7i	324	31 - 7i	388	1 - 25i	452	1 - 7i
5	33 + 5i	69	31 + 5i	133	1 + 27i	197	1 + 5i	261	33 - 5i	325	31 - 5i	389	1 - 27i	453	1 - 5i
6	35 + 7i	70	29 + 7i	134	3 + 25i	198	3 + 7i	262	35 - 7i	326	29 - 7i	390	3 - 25i	454	3 - 7i
7	35 + 5i	71	29 + 5i	135	3 + 27i	199	3 + 5i	263	35 - 5i	327	29 - 5i	391	3 - 27i	455	3 - 5i
8	7 + 33i	72	25 + 1i	136	7 + 31i	200	7 + 1i	264	7 - 33i	328	25 - 1i	392	7 - 31i	456	7 - 1i
9	7 + 35i	73	25 + 3i	137	7 + 29i	201	7 + 3i	265	7 - 35i	329	25 - 3i	393	7 - 29i	457	7 - 3i
10	5 + 33i	74	27 + 1i	138	5 + 31i	202	5 + 1i	266	5 - 33i	330	27 - 1i	394	5 - 31i	458	5 - 1i
11	5 + 35i	75	27 + 3i	139	5 + 29i	203	5 + 3i	267	5 - 35i	331	27 - 3i	395	5 - 29i	459	5 - 3i
12	25 + 25i	76	25 + 7i	140	7 + 25i	204	7 + 7i	268	25 - 25i	332	25 - 7i	396	7 - 25i	460	7 - 7i
13	25 + 27i	77	25 + 5i	141	7 + 27i	205	7 + 5i	269	25 - 27i	333	25 - 5i	397	7 - 27i	461	7 - 5i
14	27 + 25i	78	27 + 7i	142	5 + 25i	206	5 + 7i	270	27 - 25i	334	27 - 7i	398	5 - 25i	462	5 - 7i
15	37 + 5i	79	27 + 5i	143	5 + 27i	207	5 + 5i	271	5 - 37i	335	27 - 5i	399	5 - 27i	463	5 - 5i
16	31 + 17i	80	31 + 15i	144	1 + 17i	208	1 + 15i	272	31 - 17i	336	31 - 15i	400	1 - 17i	464	1 - 15i
17	33 + 13i	81	31 + 13i	145	1 + 19i	209	1 + 13i	273	33 - 13i	337	31 - 13i	401	1 - 19i	465	1 - 13i
18	29 + 17i	82	29 + 15i	146	3 + 17i	210	3 + 15i	274	29 - 17i	338	29 - 15i	402	3 - 17i	466	3 - 15i
19	29 + 19i	83	29 + 13i	147	3 + 19i	211	3 + 13i	275	29 - 19i	339	29 - 13i	403	3 - 19i	467	3 - 13i
20	33 + 9i	84	31 + 9i	148	1 + 23i	212	1 + 9i	276	33 - 9i	340	31 - 9i	404	1 - 23i	468	1 - 9i
21	33 + 11i	85	31 + 11i	149	1 + 21i	213	1 + 11i	277	33 - 11i	341	31 - 11i	405	1 - 21i	469	1 - 11i
22	35 + 9i	86	29 + 9i	150	3 + 23i	214	3 + 9i	278	35 - 9i	342	29 - 9i	406	3 - 23i	470	3 - 9i
23	29 + 21i	87	29 + 11i	151	3 + 21i	215	3 + 11i	279	29 - 21i	343	29 - 11i	407	3 - 21i	471	3 - 11i
24	25 + 17i	88	25 + 15i	152	7 + 17i	216	7 + 15i	280	25 - 17i	344	25 - 15i	408	7 - 17i	472	7 - 15i
25	25 + 19i	89	25 + 13i	153	7 + 19i	217	7 + 13i	281	25 - 19i	345	25 - 13i	409	7 - 19i	473	7 - 13i
26	27 + 17i	90	27 + 15i	154	5 + 17i	218	5 + 15i	282	27 - 17i	346	27 - 15i	410	5 - 17i	474	5 - 15i
27	27 + 19i	91	27 + 13i	155	5 + 19i	219	5 + 13i	283	27 - 19i	347	27 - 13i	411	5 - 19i	475	5 - 13i
28	25 + 23i	92	25 + 9i	156	7 + 23i	220	7 + 9i	284	25 - 23i	348	25 - 9i	412	7 - 23i	476	7 - 9i
29	25 + 21i	93	25 + 11i	157	7 + 21i	221	7 + 11i	285	25 - 21i	349	25 - 11i	413	7 - 21i	477	7 - 11i
30	27 + 23i	94	27 + 9i	158	5 + 23i	222	5 + 9i	286	27 - 23i	350	27 - 9i	414	5 - 23i	478	5 - 9i

FIG. 13

31	27 + 21i	95	27 + 11i	159	5 + 21i	223	5 + 11i	287	27 - 21i	351	27 - 11i	415	5 - 21i	479	5 - 11i
32	17 + 31i	96	17 + 1i	160	15 + 31i	224	15 + 1i	288	17 - 31i	352	17 - 1i	416	15 - 31i	480	15 - 1i
33	17 + 29i	97	17 + 3i	161	15 + 29i	225	15 + 3i	289	17 - 29i	353	17 - 3i	417	15 - 29i	481	15 - 3i
34	13 + 33i	98	19 + 1i	162	13 + 31i	226	13 + 1i	290	13 - 33i	354	19 - 1i	418	13 - 31i	482	13 - 1i
35	19 + 29i	99	19 + 3i	163	13 + 29i	227	13 + 3i	291	19 - 29i	355	19 - 3i	419	13 - 29i	483	13 - 3i
36	17 + 25i	100	17 + 7i	164	15 + 25i	228	15 + 7i	292	17 - 25i	356	17 - 7i	420	15 - 25i	484	15 - 7i
37	17 + 27i	101	17 + 5i	165	15 + 27i	229	15 + 5i	293	17 - 27i	357	17 - 5i	421	15 - 27i	485	15 - 5i
38	19 + 25i	102	19 + 7i	166	13 + 25i	230	13 + 7i	294	19 - 25i	358	19 - 7i	422	13 - 25i	486	13 - 7i
39	19 + 27i	103	19 + 5i	167	13 + 27i	231	13 + 5i	295	19 - 27i	359	19 - 5i	423	13 - 27i	487	13 - 5i
40	9 + 33i	104	23 + 1i	168	9 + 31i	232	9 + 1i	296	9 - 33i	360	23 - 1i	424	9 - 31i	488	9 - 1i
41	9 + 35i	105	23 + 3i	169	9 + 29i	233	9 + 3i	297	9 - 35i	361	23 - 3i	425	9 - 29i	489	9 - 3i
42	11 + 33i	106	21 + 1i	170	11 + 31i	234	11 + 1i	298	11 - 33i	362	21 - 1i	426	11 - 31i	490	11 - 1i
43	21 + 29i	107	21 + 3i	171	11 + 29i	235	11 + 3i	299	21 - 29i	363	21 - 3i	427	11 - 29i	491	11 - 3i
44	23 + 25i	108	23 + 7i	172	9 + 25i	236	9 + 7i	300	23 - 25i	364	23 - 7i	428	9 - 25i	492	9 - 7i
45	23 + 27i	109	23 + 5i	173	9 + 27i	237	9 + 5i	301	23 - 27i	365	23 - 5i	429	9 - 27i	493	9 - 5i
46	21 + 25i	110	21 + 7i	174	11 + 25i	238	11 + 7i	302	21 - 25i	366	21 - 7i	430	11 - 25i	494	11 - 7i
47	21 + 27i	111	21 + 5i	175	11 + 27i	239	11 + 5i	303	21 - 27i	367	21 - 5i	431	11 - 27i	495	11 - 5i
48	17 + 17i	112	17 + 15i	176	15 + 17i	240	15 + 15i	304	17 - 17i	368	17 - 15i	432	15 - 17i	496	15 - 15i
49	17 + 19i	113	17 + 13i	177	15 + 19i	241	15 + 13i	305	17 - 19i	369	17 - 13i	433	15 - 19i	497	15 - 13i
50	19 + 17i	114	19 + 15i	178	13 + 17i	242	13 + 15i	306	19 - 17i	370	19 - 15i	434	13 - 17i	498	13 - 15i
51	19 + 19i	115	19 + 13i	179	13 + 19i	243	13 + 13i	307	19 - 19i	371	19 - 13i	435	13 - 19i	499	13 - 13i
52	17 + 23i	116	17 + 9i	180	15 + 23i	244	15 + 9i	308	17 - 23i	372	17 - 9i	436	15 - 23i	500	15 - 9i
53	17 + 21i	117	17 + 11i	181	15 + 21i	245	15 + 11i	309	17 - 21i	373	17 - 11i	437	15 - 21i	501	15 - 11i
54	19 + 23i	118	19 + 9i	182	13 + 23i	246	13 + 9i	310	19 - 23i	374	19 - 9i	438	13 - 23i	502	13 - 9i
55	19 + 21i	119	19 + 11i	183	13 + 21i	247	13 + 11i	311	19 - 21i	375	19 - 11i	439	13 - 21i	503	13 - 11i
56	23 + 17i	120	23 + 15i	184	9 + 17i	248	9 + 15i	312	23 - 17i	376	23 - 15i	440	9 - 17i	504	9 - 15i
57	23 + 19i	121	23 + 13i	185	9 + 19i	249	9 + 13i	313	23 - 19i	377	23 - 13i	441	9 - 19i	505	9 - 13i
58	21 + 17i	122	21 + 15i	186	11 + 17i	250	11 + 15i	314	21 - 17i	378	21 - 15i	442	11 - 17i	506	11 - 15i
59	21 + 19i	123	21 + 13i	187	11 + 19i	251	11 + 13i	315	21 - 19i	379	21 - 13i	443	11 - 19i	507	11 - 13i
60	23 + 23i	124	23 + 9i	188	9 + 23i	252	9 + 9i	316	23 - 23i	380	23 - 9i	444	9 - 23i	508	9 - 9i
61	23 + 21i	125	23 + 11i	189	9 + 21i	253	9 + 11i	317	23 - 21i	381	23 - 11i	445	9 - 21i	509	9 - 11i
62	21 + 23i	126	21 + 9i	190	11 + 23i	254	11 + 9i	318	21 - 23i	382	21 - 9i	446	11 - 23i	510	11 - 9i
63	21 + 21i	127	21 + 11i	191	11 + 21i	255	11 + 11i	319	21 - 21i	383	21 - 11i	447	11 - 21i	511	11 - 11i

FIG. 14

Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter
512	-1 + 33i	576	-31 + 1i	640	-1 + 31i	704	-1 + 1i	768	-33 - 1i	832	-31 - 1i	896	-1 - 31i	960	-1 - 1i
513	-33 + 3i	577	-31 + 3i	641	-1 + 29i	705	-1 + 3i	769	-33 - 3i	833	-31 - 3i	897	-1 - 29i	961	-1 - 3i
514	-3 + 33i	578	-29 + 1i	642	-3 + 31i	706	-3 + 1i	770	-3 - 33i	834	-29 - 1i	898	-3 - 31i	962	-3 - 1i
515	-3 + 35i	579	-29 + 3i	643	-3 + 29i	707	-3 + 3i	771	-35 - 3i	835	-29 - 3i	899	-3 - 29i	963	-3 - 3i
516	-33 + 7i	580	-31 + 7i	644	-1 + 25i	708	-1 + 7i	772	-33 - 7i	836	-31 - 7i	900	-1 - 25i	964	-1 - 7i
517	-33 + 5i	581	-31 + 5i	645	-1 + 27i	709	-1 + 5i	773	-33 - 5i	837	-31 - 5i	901	-1 - 27i	965	-1 - 5i
518	-35 + 7i	582	-29 + 7i	646	-3 + 25i	710	-3 + 7i	774	-35 - 7i	838	-29 - 7i	902	-3 - 25i	966	-3 - 7i
519	-35 + 5i	583	-29 + 5i	647	-3 + 27i	711	-3 + 5i	775	-35 - 5i	839	-29 - 5i	903	-3 - 27i	967	-3 - 5i
520	-7 + 33i	584	-25 + 1i	648	-7 + 31i	712	-7 + 1i	776	-7 - 33i	840	-25 - 1i	904	-7 - 31i	968	-7 - 1i
521	-7 + 35i	585	-25 + 3i	649	-7 + 29i	713	-7 + 3i	777	-7 - 35i	841	-25 - 3i	905	-7 - 29i	969	-7 - 3i
522	-5 + 33i	586	-27 + 1i	650	-5 + 31i	714	-5 + 1i	778	-5 - 33i	842	-27 - 1i	906	-5 - 31i	970	-5 - 1i
523	-5 + 35i	587	-27 + 3i	651	-5 + 29i	715	-5 + 3i	779	-5 - 35i	843	-27 - 3i	907	-5 - 29i	971	-5 - 3i
524	-25 + 25i	588	-25 + 7i	652	-7 + 25i	716	-7 + 7i	780	-25 - 25i	844	-25 - 7i	908	-7 - 25i	972	-7 - 7i
525	-25 + 27i	589	-25 + 5i	653	-7 + 27i	717	-7 + 5i	781	-25 - 27i	845	-25 - 5i	909	-7 - 27i	973	-7 - 5i
526	-27 + 25i	590	-27 + 7i	654	-5 + 25i	718	-5 + 7i	782	-27 - 25i	846	-27 - 7i	910	-5 - 25i	974	-5 - 7i
527	-5 + 37i	591	-27 + 5i	655	-5 + 27i	719	-5 + 5i	783	-37 - 5i	847	-27 - 5i	911	-5 - 27i	975	-5 - 5i
528	-31 + 17i	592	-31 + 15i	656	-1 + 17i	720	-1 + 15i	784	-31 - 17i	848	-31 - 15i	912	-1 - 17i	976	-1 - 15i
529	-33 + 13i	593	-31 + 13i	657	-1 + 19i	721	-1 + 13i	785	-33 - 13i	849	-31 - 13i	913	-1 - 19i	977	-1 - 13i
530	-29 + 17i	594	-29 + 15i	658	-3 + 17i	722	-3 + 15i	786	-29 - 17i	850	-29 - 15i	914	-3 - 17i	978	-3 - 15i
531	-29 + 19i	595	-29 + 13i	659	-3 + 19i	723	-3 + 13i	787	-29 - 19i	851	-29 - 13i	915	-3 - 19i	979	-3 - 13i
532	-33 + 9i	596	-31 + 9i	660	-1 + 23i	724	-1 + 9i	788	-33 - 9i	852	-31 - 9i	916	-1 - 23i	980	-1 - 9i
533	-33 + 11i	597	-31 + 11i	661	-1 + 21i	725	-1 + 11i	789	-33 - 11i	853	-31 - 11i	917	-1 - 21i	981	-1 - 11i
534	-35 + 9i	598	-29 + 9i	662	-3 + 23i	726	-3 + 9i	790	-35 - 9i	854	-29 - 9i	918	-3 - 23i	982	-3 - 9i
535	-29 + 21i	599	-29 + 11i	663	-3 + 21i	727	-3 + 11i	791	-29 - 21i	855	-29 - 11i	919	-3 - 21i	983	-3 - 11i
536	-25 + 17i	600	-25 + 15i	664	-7 + 17i	728	-7 + 15i	792	-25 - 17i	856	-25 - 15i	920	-7 - 17i	984	-7 - 15i
537	-25 + 19i	601	-25 + 13i	665	-7 + 19i	729	-7 + 13i	793	-25 - 19i	857	-25 - 13i	921	-7 - 19i	985	-7 - 13i
538	-27 + 17i	602	-27 + 15i	666	-5 + 17i	730	-5 + 15i	794	-27 - 17i	858	-27 - 15i	922	-5 - 17i	986	-5 - 15i
539	-27 + 19i	603	-27 + 13i	667	-5 + 19i	731	-5 + 13i	795	-27 - 19i	859	-27 - 13i	923	-5 - 19i	987	-5 - 13i
540	-25 + 23i	604	-25 + 9i	668	-7 + 23i	732	-7 + 9i	796	-25 - 23i	860	-25 - 9i	924	-7 - 23i	988	-7 - 9i

FIG. 15

541	-25 + 21i	605	-25 + 11i	669	-7 + 21i	733	-7 + 11i	797	-25 - 21i	861	-25 - 11i	925	-7 - 21i	989	-7 - 11i
542	-27 + 23i	606	-27 + 9i	670	-5 + 23i	734	-5 + 9i	798	-27 - 23i	862	-27 - 9i	926	-5 - 23i	990	-5 - 9i
543	-27 + 21i	607	-27 + 11i	671	-5 + 21i	735	-5 + 11i	799	-27 - 21i	863	-27 - 11i	927	-5 - 21i	991	-5 - 11i
544	-17 + 31i	608	-17 + 1i	672	-15 + 31i	736	-15 + 1i	800	-17 - 31i	864	-17 - 1i	928	-15 - 31i	992	-15 - 1i
545	-17 + 29i	609	-17 + 3i	673	-15 + 29i	737	-15 + 3i	801	-17 - 29i	865	-17 - 3i	929	-15 - 29i	993	-15 - 3i
546	-13 + 33i	610	-19 + 1i	674	-13 + 31i	738	-13 + 1i	802	-13 - 33i	866	-19 - 1i	930	-13 - 31i	994	-13 - 1i
547	-19 + 29i	611	-19 + 3i	675	-13 + 29i	739	-13 + 3i	803	-19 - 29i	867	-19 - 3i	931	-13 - 29i	995	-13 - 3i
548	-17 + 25i	612	-17 + 7i	676	-15 + 25i	740	-15 + 7i	804	-17 - 25i	868	-17 - 7i	932	-15 - 25i	996	-15 - 7i
549	-17 + 27i	613	-17 + 5i	677	-15 + 27i	741	-15 + 5i	805	-17 - 27i	869	-17 - 5i	933	-15 - 27i	997	-15 - 5i
550	-19 + 25i	614	-19 + 7i	678	-13 + 25i	742	-13 + 7i	806	-19 - 25i	870	-19 - 7i	934	-13 - 25i	998	-13 - 7i
551	-19 + 27i	615	-19 + 5i	679	-13 + 27i	743	-13 + 5i	807	-19 - 27i	871	-19 - 5i	935	-13 - 27i	999	-13 - 5i
552	-9 + 33i	616	-23 + 1i	680	-9 + 31i	744	-9 + 1i	808	-9 - 33i	872	-23 - 1i	936	-9 - 31i	1000	-9 - 1i
553	-9 + 35i	617	-23 + 3i	681	-9 + 29i	745	-9 + 3i	809	-9 - 35i	873	-23 - 3i	937	-9 - 29i	1001	-9 - 3i
554	-11 + 33i	618	-21 + 1i	682	-11 + 31i	746	-11 + 1i	810	-11 - 33i	874	-21 - 1i	938	-11 - 31i	1002	-11 - 1i
555	-21 + 29i	619	-21 + 3i	683	-11 + 29i	747	-11 + 3i	811	-21 - 29i	875	-21 - 3i	939	-11 - 29i	1003	-11 - 3i
556	-23 + 25i	620	-23 + 7i	684	-9 + 25i	748	-9 + 7i	812	-23 - 25i	876	-23 - 7i	940	-9 - 25i	1004	-9 - 7i
557	-23 + 27i	621	-23 + 5i	685	-9 + 27i	749	-9 + 5i	813	-23 - 27i	877	-23 - 5i	941	-9 - 27i	1005	-9 - 5i
558	-21 + 25i	622	-21 + 7i	686	-11 + 25i	750	-11 + 7i	814	-21 - 25i	878	-21 - 7i	942	-11 - 25i	1006	-11 - 7i
559	-21 + 27i	623	-21 + 5i	687	-11 + 27i	751	-11 + 5i	815	-21 - 27i	879	-21 - 5i	943	-11 - 27i	1007	-11 - 5i
560	-17 + 17i	624	-17 + 15i	688	-15 + 17i	752	-15 + 15i	816	-17 - 17i	880	-17 - 15i	944	-15 - 17i	1008	-15 - 15i
561	-17 + 19i	625	-17 + 13i	689	-15 + 19i	753	-15 + 13i	817	-17 - 19i	881	-17 - 13i	945	-15 - 19i	1009	-15 - 13i
562	-19 + 17i	626	-19 + 15i	690	-13 + 17i	754	-13 + 15i	818	-19 - 17i	882	-19 - 15i	946	-13 - 17i	1010	-13 - 15i
563	-19 + 19i	627	-19 + 13i	691	-13 + 19i	755	-13 + 13i	819	-19 - 19i	883	-19 - 13i	947	-13 - 19i	1011	-13 - 13i
564	-17 + 23i	628	-17 + 9i	692	-15 + 23i	756	-15 + 9i	820	-17 - 23i	884	-17 - 9i	948	-15 - 23i	1012	-15 - 9i
565	-17 + 21i	629	-17 + 11i	693	-15 + 21i	757	-15 + 11i	821	-17 - 21i	885	-17 - 11i	949	-15 - 21i	1013	-15 - 11i
566	-19 + 23i	630	-19 + 9i	694	-13 + 23i	758	-13 + 9i	822	-19 - 23i	886	-19 - 9i	950	-13 - 23i	1014	-13 - 9i
567	-19 + 21i	631	-19 + 11i	695	-13 + 21i	759	-13 + 11i	823	-19 - 21i	887	-19 - 11i	951	-13 - 21i	1015	-13 - 11i
568	-23 + 17i	632	-23 + 15i	696	-9 + 17i	760	-9 + 15i	824	-23 - 17i	888	-23 - 15i	952	-9 - 17i	1016	-9 - 15i
569	-23 + 19i	633	-23 + 13i	697	-9 + 19i	761	-9 + 13i	825	-23 - 19i	889	-23 - 13i	953	-9 - 19i	1017	-9 - 13i
570	-21 + 17i	634	-21 + 15i	698	-11 + 17i	762	-11 + 15i	826	-21 - 17i	890	-21 - 15i	954	-11 - 17i	1018	-11 - 15i
571	-21 + 19i	635	-21 + 13i	699	-11 + 19i	763	-11 + 13i	827	-21 - 19i	891	-21 - 13i	955	-11 - 19i	1019	-11 - 13i
572	-23 + 23i	636	-23 + 9i	700	-9 + 23i	764	-9 + 9i	828	-23 - 23i	892	-23 - 9i	956	-9 - 23i	1020	-9 - 9i
573	-23 + 21i	637	-23 + 11i	701	-9 + 21i	765	-9 + 11i	829	-23 - 21i	893	-23 - 11i	957	-9 - 21i	1021	-9 - 11i
574	-21 + 23i	638	-21 + 9i	702	-11 + 23i	766	-11 + 9i	830	-21 - 23i	894	-21 - 9i	958	-11 - 23i	1022	-11 - 9i
575	-21 + 21i	639	-21 + 11i	703	-11 + 21i	767	-11 + 11i	831	-21 - 21i	895	-21 - 11i	959	-11 - 21i	1023	-11 - 11i

FIG. 16

Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter
0	65 + 1i	64	63 + 33i	128	33 + 63i	192	33 + 33i	256	63 + 1i	320	63 + 31i	384	33 + 1i	448	33 + 31i
1	65 + 3i	65	65 + 29i	129	33 + 61i	193	33 + 35i	257	63 + 3i	321	63 + 29i	385	33 + 3i	449	33 + 29i
2	3 + 65i	66	61 + 33i	130	29 + 65i	194	35 + 33i	258	61 + 1i	322	61 + 31i	386	35 + 1i	450	35 + 31i
3	67 + 3i	67	61 + 35i	131	35 + 61i	195	35 + 35i	259	61 + 3i	323	61 + 29i	387	35 + 3i	451	35 + 29i
4	65 + 7i	68	65 + 25i	132	33 + 57i	196	33 + 39i	260	63 + 7i	324	63 + 25i	388	33 + 7i	452	33 + 25i
5	65 + 5i	69	65 + 27i	133	33 + 59i	197	33 + 37i	261	63 + 5i	325	63 + 27i	389	33 + 5i	453	33 + 27i
6	67 + 7i	70	67 + 25i	134	35 + 57i	198	35 + 39i	262	61 + 7i	326	61 + 25i	390	35 + 7i	454	35 + 25i
7	67 + 5i	71	61 + 37i	135	35 + 59i	199	35 + 37i	263	61 + 5i	327	61 + 27i	391	35 + 5i	455	35 + 27i
8	7 + 65i	72	57 + 33i	136	25 + 65i	200	39 + 33i	264	57 + 1i	328	57 + 31i	392	39 + 1i	456	39 + 31i
9	7 + 67i	73	57 + 35i	137	25 + 67i	201	39 + 35i	265	57 + 3i	329	57 + 29i	393	39 + 3i	457	39 + 29i
10	5 + 65i	74	59 + 33i	138	27 + 65i	202	37 + 33i	266	59 + 1i	330	59 + 31i	394	37 + 1i	458	37 + 31i
11	5 + 67i	75	59 + 35i	139	37 + 61i	203	37 + 35i	267	59 + 3i	331	59 + 29i	395	37 + 3i	459	37 + 29i
12	71 + 7i	76	57 + 39i	140	39 + 57i	204	39 + 39i	268	57 + 7i	332	57 + 25i	396	39 + 7i	460	39 + 25i
13	7 + 69i	77	57 + 37i	141	39 + 59i	205	39 + 37i	269	57 + 5i	333	57 + 27i	397	39 + 5i	461	39 + 27i
14	69 + 7i	78	59 + 39i	142	37 + 57i	206	37 + 39i	270	59 + 7i	334	59 + 25i	398	37 + 7i	462	37 + 25i
15	69 + 5i	79	59 + 37i	143	37 + 59i	207	37 + 37i	271	59 + 5i	335	59 + 27i	399	37 + 5i	463	37 + 27i
16	65 + 15i	80	65 + 17i	144	33 + 49i	208	33 + 47i	272	63 + 15i	336	63 + 17i	400	33 + 15i	464	33 + 17i
17	65 + 13i	81	65 + 19i	145	33 + 51i	209	33 + 45i	273	63 + 13i	337	63 + 19i	401	33 + 13i	465	33 + 19i
18	67 + 15i	82	67 + 17i	146	35 + 49i	210	35 + 47i	274	61 + 15i	338	61 + 17i	402	35 + 15i	466	35 + 17i
19	67 + 13i	83	67 + 19i	147	35 + 51i	211	35 + 45i	275	61 + 13i	339	61 + 19i	403	35 + 13i	467	35 + 19i
20	65 + 9i	84	65 + 23i	148	33 + 55i	212	33 + 41i	276	63 + 9i	340	63 + 23i	404	33 + 9i	468	33 + 23i
21	65 + 11i	85	65 + 21i	149	33 + 53i	213	33 + 43i	277	63 + 11i	341	63 + 21i	405	33 + 11i	469	33 + 21i
22	67 + 9i	86	67 + 23i	150	35 + 55i	214	35 + 41i	278	61 + 9i	342	61 + 23i	406	35 + 9i	470	35 + 23i
23	67 + 11i	87	67 + 21i	151	35 + 53i	215	35 + 43i	279	61 + 11i	343	61 + 21i	407	35 + 11i	471	35 + 21i
24	71 + 15i	88	71 + 17i	152	39 + 49i	216	39 + 47i	280	57 + 15i	344	57 + 17i	408	39 + 15i	472	39 + 17i
25	71 + 13i	89	57 + 45i	153	39 + 51i	217	39 + 45i	281	57 + 13i	345	57 + 19i	409	39 + 13i	473	39 + 19i
26	69 + 15i	90	69 + 17i	154	37 + 49i	218	37 + 47i	282	59 + 15i	346	59 + 17i	410	37 + 15i	474	37 + 17i
27	69 + 13i	91	69 + 19i	155	37 + 51i	219	37 + 45i	283	59 + 13i	347	59 + 19i	411	37 + 13i	475	37 + 19i
28	71 + 9i	92	57 + 41i	156	39 + 55i	220	39 + 41i	284	57 + 9i	348	57 + 23i	412	39 + 9i	476	39 + 23i
29	71 + 11i	93	57 + 43i	157	39 + 53i	221	39 + 43i	285	57 + 11i	349	57 + 21i	413	39 + 11i	477	39 + 21i
30	69 + 9i	94	59 + 41i	158	37 + 55i	222	37 + 41i	286	59 + 9i	350	59 + 23i	414	37 + 9i	478	37 + 23i

FIG. 17

31	69 + 11i	95	69 + 21i	159	37 + 53i	223	37 + 43i	287	59 + 11i	351	59 + 21i	415	37 + 11i	479	37 + 21i
32	15 + 65i	96	49 + 33i	160	17 + 65i	224	47 + 33i	288	49 + 1i	352	49 + 31i	416	47 + 1i	480	47 + 31i
33	15 + 67i	97	49 + 35i	161	17 + 67i	225	47 + 35i	289	49 + 3i	353	49 + 29i	417	47 + 3i	481	47 + 29i
34	13 + 65i	98	51 + 33i	162	19 + 65i	226	45 + 33i	290	51 + 1i	354	51 + 31i	418	45 + 1i	482	45 + 31i
35	13 + 67i	99	51 + 35i	163	19 + 67i	227	45 + 35i	291	51 + 3i	355	51 + 29i	419	45 + 3i	483	45 + 29i
36	15 + 71i	100	49 + 39i	164	17 + 71i	228	47 + 39i	292	49 + 7i	356	49 + 25i	420	47 + 7i	484	47 + 25i
37	15 + 69i	101	49 + 37i	165	17 + 69i	229	47 + 37i	293	49 + 5i	357	49 + 27i	421	47 + 5i	485	47 + 27i
38	13 + 71i	102	51 + 39i	166	45 + 57i	230	45 + 39i	294	51 + 7i	358	51 + 25i	422	45 + 7i	486	45 + 25i
39	13 + 69i	103	51 + 37i	167	19 + 69i	231	45 + 37i	295	51 + 5i	359	51 + 27i	423	45 + 5i	487	45 + 27i
40	9 + 65i	104	55 + 33i	168	23 + 65i	232	41 + 33i	296	55 + 1i	360	55 + 31i	424	41 + 1i	488	41 + 31i
41	9 + 67i	105	55 + 35i	169	23 + 67i	233	41 + 35i	297	55 + 3i	361	55 + 29i	425	41 + 3i	489	41 + 29i
42	11 + 65i	106	53 + 33i	170	21 + 65i	234	43 + 33i	298	53 + 1i	362	53 + 31i	426	43 + 1i	490	43 + 31i
43	11 + 67i	107	53 + 35i	171	21 + 67i	235	43 + 35i	299	53 + 3i	363	53 + 29i	427	43 + 3i	491	43 + 29i
44	9 + 71i	108	55 + 39i	172	41 + 57i	236	41 + 39i	300	55 + 7i	364	55 + 25i	428	41 + 7i	492	41 + 25i
45	9 + 69i	109	55 + 37i	173	41 + 59i	237	41 + 37i	301	55 + 5i	365	55 + 27i	429	41 + 5i	493	41 + 27i
46	11 + 71i	110	53 + 39i	174	43 + 57i	238	43 + 39i	302	53 + 7i	366	53 + 25i	430	43 + 7i	494	43 + 25i
47	11 + 69i	111	53 + 37i	175	21 + 69i	239	43 + 37i	303	53 + 5i	367	53 + 27i	431	43 + 5i	495	43 + 27i
48	49 + 49i	112	49 + 47i	176	47 + 49i	240	47 + 47i	304	49 + 15i	368	49 + 17i	432	47 + 15i	496	47 + 17i
49	49 + 51i	113	49 + 45i	177	47 + 51i	241	47 + 45i	305	49 + 13i	369	49 + 19i	433	47 + 13i	497	47 + 19i
50	51 + 49i	114	51 + 47i	178	45 + 49i	242	45 + 47i	306	51 + 15i	370	51 + 17i	434	45 + 15i	498	45 + 17i
51	51 + 51i	115	51 + 45i	179	45 + 51i	243	45 + 45i	307	51 + 13i	371	51 + 19i	435	45 + 13i	499	45 + 19i
52	49 + 55i	116	49 + 41i	180	47 + 55i	244	47 + 41i	308	49 + 9i	372	49 + 23i	436	47 + 9i	500	47 + 23i
53	49 + 53i	117	49 + 43i	181	47 + 53i	245	47 + 43i	309	49 + 11i	373	49 + 21i	437	47 + 11i	501	47 + 21i
54	13 + 73i	118	51 + 41i	182	45 + 55i	246	45 + 41i	310	51 + 9i	374	51 + 23i	438	45 + 9i	502	45 + 23i
55	51 + 53i	119	51 + 43i	183	45 + 53i	247	45 + 43i	311	51 + 11i	375	51 + 21i	439	45 + 11i	503	45 + 21i
56	55 + 49i	120	55 + 47i	184	41 + 49i	248	41 + 47i	312	55 + 15i	376	55 + 17i	440	41 + 15i	504	41 + 17i
57	73 + 13i	121	55 + 45i	185	41 + 51i	249	41 + 45i	313	55 + 13i	377	55 + 19i	441	41 + 13i	505	41 + 19i
58	53 + 49i	122	53 + 47i	186	43 + 49i	250	43 + 47i	314	53 + 15i	378	53 + 17i	442	43 + 15i	506	43 + 17i
59	53 + 51i	123	53 + 45i	187	43 + 51i	251	43 + 45i	315	53 + 13i	379	53 + 19i	443	43 + 13i	507	43 + 19i
60	73 + 9i	124	55 + 41i	188	41 + 55i	252	41 + 41i	316	55 + 9i	380	55 + 23i	444	41 + 9i	508	41 + 23i
61	73 + 11i	125	55 + 43i	189	41 + 53i	253	41 + 43i	317	55 + 11i	381	55 + 21i	445	41 + 11i	509	41 + 21i
62	11 + 73i	126	53 + 41i	190	43 + 55i	254	43 + 41i	318	53 + 9i	382	53 + 23i	446	43 + 9i	510	43 + 23i
63	53 + 53i	127	53 + 43i	191	43 + 53i	255	43 + 43i	319	53 + 11i	383	53 + 21i	447	43 + 11i	511	43 + 21i

FIG. 18

Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter
512	1 + 63i	576	1 + 33i	640	31 + 63i	704	31 + 33i	768	1 + 1i	832	1 + 31i	896	31 + 1i	960	31 + 31i
513	1 + 61i	577	1 + 35i	641	31 + 61i	705	31 + 35i	769	1 + 3i	833	1 + 29i	897	31 + 3i	961	31 + 29i
514	3 + 63i	578	3 + 33i	642	29 + 63i	706	29 + 33i	770	3 + 1i	834	3 + 31i	898	29 + 1i	962	29 + 31i
515	3 + 61i	579	3 + 35i	643	29 + 61i	707	29 + 35i	771	3 + 3i	835	3 + 29i	899	29 + 3i	963	29 + 29i
516	1 + 57i	580	1 + 39i	644	31 + 57i	708	31 + 39i	772	1 + 7i	836	1 + 25i	900	31 + 7i	964	31 + 25i
517	1 + 59i	581	1 + 37i	645	31 + 59i	709	31 + 37i	773	1 + 5i	837	1 + 27i	901	31 + 5i	965	31 + 27i
518	3 + 57i	582	3 + 39i	646	29 + 57i	710	29 + 39i	774	3 + 7i	838	3 + 25i	902	29 + 7i	966	29 + 25i
519	3 + 59i	583	3 + 37i	647	29 + 59i	711	29 + 37i	775	3 + 5i	839	3 + 27i	903	29 + 5i	967	29 + 27i
520	7 + 63i	584	7 + 33i	648	25 + 63i	712	25 + 33i	776	7 + 1i	840	7 + 31i	904	25 + 1i	968	25 + 31i
521	7 + 61i	585	7 + 35i	649	25 + 61i	713	25 + 35i	777	7 + 3i	841	7 + 29i	905	25 + 3i	969	25 + 29i
522	5 + 63i	586	5 + 33i	650	27 + 63i	714	27 + 33i	778	5 + 1i	842	5 + 31i	906	27 + 1i	970	27 + 31i
523	5 + 61i	587	5 + 35i	651	27 + 61i	715	27 + 35i	779	5 + 3i	843	5 + 29i	907	27 + 3i	971	27 + 29i
524	7 + 57i	588	7 + 39i	652	25 + 57i	716	25 + 39i	780	7 + 7i	844	7 + 25i	908	25 + 7i	972	25 + 25i
525	7 + 59i	589	7 + 37i	653	25 + 59i	717	25 + 37i	781	7 + 5i	845	7 + 27i	909	25 + 5i	973	25 + 27i
526	5 + 57i	590	5 + 39i	654	27 + 57i	718	27 + 39i	782	5 + 7i	846	5 + 25i	910	27 + 7i	974	27 + 25i
527	5 + 59i	591	5 + 37i	655	27 + 59i	719	27 + 37i	783	5 + 5i	847	5 + 27i	911	27 + 5i	975	27 + 27i
528	1 + 49i	592	1 + 47i	656	31 + 49i	720	31 + 47i	784	1 + 15i	848	1 + 17i	912	31 + 15i	976	31 + 17i
529	1 + 51i	593	1 + 45i	657	31 + 51i	721	31 + 45i	785	1 + 13i	849	1 + 19i	913	31 + 13i	977	31 + 19i
530	3 + 49i	594	3 + 47i	658	29 + 49i	722	29 + 47i	786	3 + 15i	850	3 + 17i	914	29 + 15i	978	29 + 17i
531	3 + 51i	595	3 + 45i	659	29 + 51i	723	29 + 45i	787	3 + 13i	851	3 + 19i	915	29 + 13i	979	29 + 19i
532	1 + 55i	596	1 + 41i	660	31 + 55i	724	31 + 41i	788	1 + 9i	852	1 + 23i	916	31 + 9i	980	31 + 23i
533	1 + 53i	597	1 + 43i	661	31 + 53i	725	31 + 43i	789	1 + 11i	853	1 + 21i	917	31 + 11i	981	31 + 21i
534	3 + 55i	598	3 + 41i	662	29 + 55i	726	29 + 41i	790	3 + 9i	854	3 + 23i	918	29 + 9i	982	29 + 23i
535	3 + 53i	599	3 + 43i	663	29 + 53i	727	29 + 43i	791	3 + 11i	855	3 + 21i	919	29 + 11i	983	29 + 21i
536	7 + 49i	600	7 + 47i	664	25 + 49i	728	25 + 47i	792	7 + 15i	856	7 + 17i	920	25 + 15i	984	25 + 17i
537	7 + 51i	601	7 + 45i	665	25 + 51i	729	25 + 45i	793	7 + 13i	857	7 + 19i	921	25 + 13i	985	25 + 19i
538	5 + 49i	602	5 + 47i	666	27 + 49i	730	27 + 47i	794	5 + 15i	858	5 + 17i	922	27 + 15i	986	27 + 17i
539	5 + 51i	603	5 + 45i	667	27 + 51i	731	27 + 45i	795	5 + 13i	859	5 + 19i	923	27 + 13i	987	27 + 19i
540	7 + 55i	604	7 + 41i	668	25 + 55i	732	25 + 41i	796	7 + 9i	860	7 + 23i	924	25 + 9i	988	25 + 23i

FIG. 19

541	7 + 53i	605	7 + 43i	669	25 + 53i	733	25 + 43i	797	7 + 11i	861	7 + 21i	925	25 + 11i	989	25 + 21i
542	5 + 55i	606	5 + 41i	670	27 + 55i	734	27 + 41i	798	5 + 9i	862	5 + 23i	926	27 + 9i	990	27 + 23i
543	5 + 53i	607	5 + 43i	671	27 + 53i	735	27 + 43i	799	5 + 11i	863	5 + 21i	927	27 + 11i	991	27 + 21i
544	15 + 63i	608	15 + 33i	672	17 + 63i	736	17 + 33i	800	15 + 1i	864	15 + 31i	928	17 + 1i	992	17 + 31i
545	15 + 61i	609	15 + 35i	673	17 + 61i	737	17 + 35i	801	15 + 3i	865	15 + 29i	929	17 + 3i	993	17 + 29i
546	13 + 63i	610	13 + 33i	674	19 + 63i	738	19 + 33i	802	13 + 1i	866	13 + 31i	930	19 + 1i	994	19 + 31i
547	13 + 61i	611	13 + 35i	675	19 + 61i	739	19 + 35i	803	13 + 3i	867	13 + 29i	931	19 + 3i	995	19 + 29i
548	15 + 57i	612	15 + 39i	676	17 + 57i	740	17 + 39i	804	15 + 7i	868	15 + 25i	932	17 + 7i	996	17 + 25i
549	15 + 59i	613	15 + 37i	677	17 + 59i	741	17 + 37i	805	15 + 5i	869	15 + 27i	933	17 + 5i	997	17 + 27i
550	13 + 57i	614	13 + 39i	678	19 + 57i	742	19 + 39i	806	13 + 7i	870	13 + 25i	934	19 + 7i	998	19 + 25i
551	13 + 59i	615	13 + 37i	679	19 + 59i	743	19 + 37i	807	13 + 5i	871	13 + 27i	935	19 + 5i	999	19 + 27i
552	9 + 63i	616	9 + 33i	680	23 + 63i	744	23 + 33i	808	9 + 1i	872	9 + 31i	936	23 + 1i	1000	23 + 31i
553	9 + 61i	617	9 + 35i	681	23 + 61i	745	23 + 35i	809	9 + 3i	873	9 + 29i	937	23 + 3i	1001	23 + 29i
554	11 + 63i	618	11 + 33i	682	21 + 63i	746	21 + 33i	810	11 + 1i	874	11 + 31i	938	21 + 1i	1002	21 + 31i
555	11 + 61i	619	11 + 35i	683	21 + 61i	747	21 + 35i	811	11 + 3i	875	11 + 29i	939	21 + 3i	1003	21 + 29i
556	9 + 57i	620	9 + 39i	684	23 + 57i	748	23 + 39i	812	9 + 7i	876	9 + 25i	940	23 + 7i	1004	23 + 25i
557	9 + 59i	621	9 + 37i	685	23 + 59i	749	23 + 37i	813	9 + 5i	877	9 + 27i	941	23 + 5i	1005	23 + 27i
558	11 + 57i	622	11 + 39i	686	21 + 57i	750	21 + 39i	814	11 + 7i	878	11 + 25i	942	21 + 7i	1006	21 + 25i
559	11 + 59i	623	11 + 37i	687	21 + 59i	751	21 + 37i	815	11 + 5i	879	11 + 27i	943	21 + 5i	1007	21 + 27i
560	15 + 49i	624	15 + 47i	688	17 + 49i	752	17 + 47i	816	15 + 15i	880	15 + 17i	944	17 + 15i	1008	17 + 17i
561	15 + 51i	625	15 + 45i	689	17 + 51i	753	17 + 45i	817	15 + 13i	881	15 + 19i	945	17 + 13i	1009	17 + 19i
562	13 + 49i	626	13 + 47i	690	19 + 49i	754	19 + 47i	818	13 + 15i	882	13 + 17i	946	19 + 15i	1010	19 + 17i
563	13 + 51i	627	13 + 45i	691	19 + 51i	755	19 + 45i	819	13 + 13i	883	13 + 19i	947	19 + 13i	1011	19 + 19i
564	15 + 55i	628	15 + 41i	692	17 + 55i	756	17 + 41i	820	15 + 9i	884	15 + 23i	948	17 + 9i	1012	17 + 23i
565	15 + 53i	629	15 + 43i	693	17 + 53i	757	17 + 43i	821	15 + 11i	885	15 + 21i	949	17 + 11i	1013	17 + 21i
566	13 + 55i	630	13 + 41i	694	19 + 55i	758	19 + 41i	822	13 + 9i	886	13 + 23i	950	19 + 9i	1014	19 + 23i
567	13 + 53i	631	13 + 43i	695	19 + 53i	759	19 + 43i	823	13 + 11i	887	13 + 21i	951	19 + 11i	1015	19 + 21i
568	9 + 49i	632	9 + 47i	696	23 + 49i	760	23 + 47i	824	9 + 15i	888	9 + 17i	952	23 + 15i	1016	23 + 17i
569	9 + 51i	633	9 + 45i	697	23 + 51i	761	23 + 45i	825	9 + 13i	889	9 + 19i	953	23 + 13i	1017	23 + 19i
570	11 + 49i	634	11 + 47i	698	21 + 49i	762	21 + 47i	826	11 + 15i	890	11 + 17i	954	21 + 15i	1018	21 + 17i
571	11 + 51i	635	11 + 45i	699	21 + 51i	763	21 + 45i	827	11 + 13i	891	11 + 19i	955	21 + 13i	1019	21 + 19i
572	9 + 55i	636	9 + 41i	700	23 + 55i	764	23 + 41i	828	9 + 9i	892	9 + 23i	956	23 + 9i	1020	23 + 23i
573	9 + 53i	637	9 + 43i	701	23 + 53i	765	23 + 43i	829	9 + 11i	893	9 + 21i	957	23 + 11i	1021	23 + 21i
574	11 + 55i	638	11 + 41i	702	21 + 55i	766	21 + 41i	830	11 + 9i	894	11 + 23i	958	21 + 9i	1022	21 + 23i
575	11 + 53i	639	11 + 43i	703	21 + 53i	767	21 + 43i	831	11 + 11i	895	11 + 21i	959	21 + 11i	1023	21 + 21i

FIG. 20

Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter
1024	1 - 65i	1088	63 - 33i	1152	33 - 63i	1216	33 - 33i	1280	63 - 1i	1344	63 - 31i	1408	33 - 1i	1472	33 - 31i
1025	65 - 3i	1089	65 - 29i	1153	33 - 61i	1217	33 - 35i	1281	63 - 3i	1345	63 - 29i	1409	33 - 3i	1473	33 - 29i
1026	3 - 65i	1090	61 - 33i	1154	29 - 65i	1218	35 - 33i	1282	61 - 1i	1346	61 - 31i	1410	35 - 1i	1474	35 - 31i
1027	3 - 67i	1091	61 - 35i	1155	35 - 61i	1219	35 - 35i	1283	61 - 3i	1347	61 - 29i	1411	35 - 3i	1475	35 - 29i
1028	65 - 7i	1092	65 - 25i	1156	33 - 57i	1220	33 - 39i	1284	63 - 7i	1348	63 - 25i	1412	33 - 7i	1476	33 - 25i
1029	65 - 5i	1093	65 - 27i	1157	33 - 59i	1221	33 - 37i	1285	63 - 5i	1349	63 - 27i	1413	33 - 5i	1477	33 - 27i
1030	67 - 7i	1094	67 - 25i	1158	35 - 57i	1222	35 - 39i	1286	61 - 7i	1350	61 - 25i	1414	35 - 7i	1478	35 - 25i
1031	67 - 5i	1095	61 - 37i	1159	35 - 59i	1223	35 - 37i	1287	61 - 5i	1351	61 - 27i	1415	35 - 5i	1479	35 - 27i
1032	7 - 65i	1096	57 - 33i	1160	25 - 65i	1224	39 - 33i	1288	57 - 1i	1352	57 - 31i	1416	39 - 1i	1480	39 - 31i
1033	7 - 67i	1097	57 - 35i	1161	25 - 67i	1225	39 - 35i	1289	57 - 3i	1353	57 - 29i	1417	39 - 3i	1481	39 - 29i
1034	5 - 65i	1098	59 - 33i	1162	27 - 65i	1226	37 - 33i	1290	59 - 1i	1354	59 - 31i	1418	37 - 1i	1482	37 - 31i
1035	5 - 67i	1099	59 - 35i	1163	37 - 61i	1227	37 - 35i	1291	59 - 3i	1355	59 - 29i	1419	37 - 3i	1483	37 - 29i
1036	7 - 71i	1100	57 - 39i	1164	39 - 57i	1228	39 - 39i	1292	57 - 7i	1356	57 - 25i	1420	39 - 7i	1484	39 - 25i
1037	7 - 69i	1101	57 - 37i	1165	39 - 59i	1229	39 - 37i	1293	57 - 5i	1357	57 - 27i	1421	39 - 5i	1485	39 - 27i
1038	69 - 7i	1102	59 - 39i	1166	37 - 57i	1230	37 - 39i	1294	59 - 7i	1358	59 - 25i	1422	37 - 7i	1486	37 - 25i
1039	5 - 69i	1103	59 - 37i	1167	37 - 59i	1231	37 - 37i	1295	59 - 5i	1359	59 - 27i	1423	37 - 5i	1487	37 - 27i
1040	65 - 15i	1104	65 - 17i	1168	33 - 49i	1232	33 - 47i	1296	63 - 15i	1360	63 - 17i	1424	33 - 15i	1488	33 - 17i
1041	65 - 13i	1105	65 - 19i	1169	33 - 51i	1233	33 - 45i	1297	63 - 13i	1361	63 - 19i	1425	33 - 13i	1489	33 - 19i
1042	67 - 15i	1106	67 - 17i	1170	35 - 49i	1234	35 - 47i	1298	61 - 15i	1362	61 - 17i	1426	35 - 15i	1490	35 - 17i
1043	67 - 13i	1107	67 - 19i	1171	35 - 51i	1235	35 - 45i	1299	61 - 13i	1363	61 - 19i	1427	35 - 13i	1491	35 - 19i
1044	65 - 9i	1108	65 - 23i	1172	33 - 55i	1236	33 - 41i	1300	63 - 9i	1364	63 - 23i	1428	33 - 9i	1492	33 - 23i
1045	65 - 11i	1109	65 - 21i	1173	33 - 53i	1237	33 - 43i	1301	63 - 11i	1365	63 - 21i	1429	33 - 11i	1493	33 - 21i
1046	67 - 9i	1110	67 - 23i	1174	35 - 55i	1238	35 - 41i	1302	61 - 9i	1366	61 - 23i	1430	35 - 9i	1494	35 - 23i
1047	67 - 11i	1111	67 - 21i	1175	35 - 53i	1239	35 - 43i	1303	61 - 11i	1367	61 - 21i	1431	35 - 11i	1495	35 - 21i
1048	71 - 15i	1112	71 - 17i	1176	39 - 49i	1240	39 - 47i	1304	57 - 15i	1368	57 - 17i	1432	39 - 15i	1496	39 - 17i
1049	71 - 13i	1113	57 - 45i	1177	39 - 51i	1241	39 - 45i	1305	57 - 13i	1369	57 - 19i	1433	39 - 13i	1497	39 - 19i
1050	69 - 15i	1114	69 - 17i	1178	37 - 49i	1242	37 - 47i	1306	59 - 15i	1370	59 - 17i	1434	37 - 15i	1498	37 - 17i
1051	69 - 13i	1115	69 - 19i	1179	37 - 51i	1243	37 - 45i	1307	59 - 13i	1371	59 - 19i	1435	37 - 13i	1499	37 - 19i
1052	71 - 9i	1116	57 - 41i	1180	39 - 55i	1244	39 - 41i	1308	57 - 9i	1372	57 - 23i	1436	39 - 9i	1500	39 - 23i
1053	71 - 11i	1117	57 - 43i	1181	39 - 53i	1245	39 - 43i	1309	57 - 11i	1373	57 - 21i	1437	39 - 11i	1501	39 - 21i
1054	69 - 9i	1118	59 - 41i	1182	37 - 55i	1246	37 - 41i	1310	59 - 9i	1374	59 - 23i	1438	37 - 9i	1502	37 - 23i
1055	69 - 11i	1119	69 - 21i	1183	37 - 53i	1247	37 - 43i	1311	59 - 11i	1375	59 - 21i	1439	37 - 11i	1503	37 - 21i

FIG. 21

1056	15 - 65i	1120	49 - 33i	1184	17 - 65i	1248	47 - 33i	1312	49 - 1i	1376	49 - 31i	1440	47 - 1i	1504	47 - 31i
1057	15 - 67i	1121	49 - 35i	1185	17 - 67i	1249	47 - 35i	1313	49 - 3i	1377	49 - 29i	1441	47 - 3i	1505	47 - 29i
1058	13 - 65i	1122	51 - 33i	1186	19 - 65i	1250	45 - 33i	1314	51 - 1i	1378	51 - 31i	1442	45 - 1i	1506	45 - 31i
1059	13 - 67i	1123	51 - 35i	1187	19 - 67i	1251	45 - 35i	1315	51 - 3i	1379	51 - 29i	1443	45 - 3i	1507	45 - 29i
1060	15 - 71i	1124	49 - 39i	1188	17 - 71i	1252	47 - 39i	1316	49 - 7i	1380	49 - 25i	1444	47 - 7i	1508	47 - 25i
1061	15 - 69i	1125	49 - 37i	1189	17 - 69i	1253	47 - 37i	1317	49 - 5i	1381	49 - 27i	1445	47 - 5i	1509	47 - 27i
1062	13 - 71i	1126	51 - 39i	1190	45 - 57i	1254	45 - 39i	1318	51 - 7i	1382	51 - 25i	1446	45 - 7i	1510	45 - 25i
1063	13 - 69i	1127	51 - 37i	1191	19 - 69i	1255	45 - 37i	1319	51 - 5i	1383	51 - 27i	1447	45 - 5i	1511	45 - 27i
1064	9 - 65i	1128	55 - 33i	1192	23 - 65i	1256	41 - 33i	1320	55 - 1i	1384	55 - 31i	1448	41 - 1i	1512	41 - 31i
1065	9 - 67i	1129	55 - 35i	1193	23 - 67i	1257	41 - 35i	1321	55 - 3i	1385	55 - 29i	1449	41 - 3i	1513	41 - 29i
1066	11 - 65i	1130	53 - 33i	1194	21 - 65i	1258	43 - 33i	1322	53 - 1i	1386	53 - 31i	1450	43 - 1i	1514	43 - 31i
1067	11 - 67i	1131	53 - 35i	1195	21 - 67i	1259	43 - 35i	1323	53 - 3i	1387	53 - 29i	1451	43 - 3i	1515	43 - 29i
1068	9 - 71i	1132	55 - 39i	1196	41 - 57i	1260	41 - 39i	1324	55 - 7i	1388	55 - 25i	1452	41 - 7i	1516	41 - 25i
1069	9 - 69i	1133	55 - 37i	1197	41 - 59i	1261	41 - 37i	1325	55 - 5i	1389	55 - 27i	1453	41 - 5i	1517	41 - 27i
1070	11 - 71i	1134	53 - 39i	1198	43 - 57i	1262	43 - 39i	1326	53 - 7i	1390	53 - 25i	1454	43 - 7i	1518	43 - 25i
1071	11 - 69i	1135	53 - 37i	1199	21 - 69i	1263	43 - 37i	1327	53 - 5i	1391	53 - 27i	1455	43 - 5i	1519	43 - 27i
1072	49 - 49i	1136	49 - 47i	1200	47 - 49i	1264	47 - 47i	1328	49 - 15i	1392	49 - 17i	1456	47 - 15i	1520	47 - 17i
1073	49 - 51i	1137	49 - 45i	1201	47 - 51i	1265	47 - 45i	1329	49 - 13i	1393	49 - 19i	1457	47 - 13i	1521	47 - 19i
1074	51 - 49i	1138	51 - 47i	1202	45 - 49i	1266	45 - 47i	1330	51 - 15i	1394	51 - 17i	1458	45 - 15i	1522	45 - 17i
1075	51 - 51i	1139	51 - 45i	1203	45 - 51i	1267	45 - 45i	1331	51 - 13i	1395	51 - 19i	1459	45 - 13i	1523	45 - 19i
1076	49 - 55i	1140	49 - 41i	1204	47 - 55i	1268	47 - 41i	1332	49 - 9i	1396	49 - 23i	1460	47 - 9i	1524	47 - 23i
1077	49 - 53i	1141	49 - 43i	1205	47 - 53i	1269	47 - 43i	1333	49 - 11i	1397	49 - 21i	1461	47 - 11i	1525	47 - 21i
1078	13 - 73i	1142	51 - 41i	1206	45 - 55i	1270	45 - 41i	1334	51 - 9i	1398	51 - 23i	1462	45 - 9i	1526	45 - 23i
1079	51 - 53i	1143	51 - 43i	1207	45 - 53i	1271	45 - 43i	1335	51 - 11i	1399	51 - 21i	1463	45 - 11i	1527	45 - 21i
1080	55 - 49i	1144	55 - 47i	1208	41 - 49i	1272	41 - 47i	1336	55 - 15i	1400	55 - 17i	1464	41 - 15i	1528	41 - 17i
1081	73 - 13i	1145	55 - 45i	1209	41 - 51i	1273	41 - 45i	1337	55 - 13i	1401	55 - 19i	1465	41 - 13i	1529	41 - 19i
1082	53 - 49i	1146	53 - 47i	1210	43 - 49i	1274	43 - 47i	1338	53 - 15i	1402	53 - 17i	1466	43 - 15i	1530	43 - 17i
1083	53 - 51i	1147	53 - 45i	1211	43 - 51i	1275	43 - 45i	1339	53 - 13i	1403	53 - 19i	1467	43 - 13i	1531	43 - 19i
1084	9 - 73i	1148	55 - 41i	1212	41 - 55i	1276	41 - 41i	1340	55 - 9i	1404	55 - 23i	1468	41 - 9i	1532	41 - 23i
1085	73 - 11i	1149	55 - 43i	1213	41 - 53i	1277	41 - 43i	1341	55 - 11i	1405	55 - 21i	1469	41 - 11i	1533	41 - 21i
1086	11 - 73i	1150	53 - 41i	1214	43 - 55i	1278	43 - 41i	1342	53 - 9i	1406	53 - 23i	1470	43 - 9i	1534	43 - 23i
1087	53 - 53i	1151	53 - 43i	1215	43 - 53i	1279	43 - 43i	1343	53 - 11i	1407	53 - 21i	1471	43 - 11i	1535	43 - 21i

FIG. 22

Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter
1536	1 - 63i	1600	1 - 33i	1664	31 - 63i	1728	31 - 33i	1792	1 - 1i	1856	1 - 31i	1920	31 - 1i	1984	31 - 31i
1537	1 - 61i	1601	1 - 35i	1665	31 - 61i	1729	31 - 35i	1793	1 - 3i	1857	1 - 29i	1921	31 - 3i	1985	31 - 29i
1538	3 - 63i	1602	3 - 33i	1666	29 - 63i	1730	29 - 33i	1794	3 - 1i	1858	3 - 31i	1922	29 - 1i	1986	29 - 31i
1539	3 - 61i	1603	3 - 35i	1667	29 - 61i	1731	29 - 35i	1795	3 - 3i	1859	3 - 29i	1923	29 - 3i	1987	29 - 29i
1540	1 - 57i	1604	1 - 39i	1668	31 - 57i	1732	31 - 39i	1796	1 - 7i	1860	1 - 25i	1924	31 - 7i	1988	31 - 25i
1541	1 - 59i	1605	1 - 37i	1669	31 - 59i	1733	31 - 37i	1797	1 - 5i	1861	1 - 27i	1925	31 - 5i	1989	31 - 27i
1542	3 - 57i	1606	3 - 39i	1670	29 - 57i	1734	29 - 39i	1798	3 - 7i	1862	3 - 25i	1926	29 - 7i	1990	29 - 25i
1543	3 - 59i	1607	3 - 37i	1671	29 - 59i	1735	29 - 37i	1799	3 - 5i	1863	3 - 27i	1927	29 - 5i	1991	29 - 27i
1544	7 - 63i	1608	7 - 33i	1672	25 - 63i	1736	25 - 33i	1800	7 - 1i	1864	7 - 31i	1928	25 - 1i	1992	25 - 31i
1545	7 - 61i	1609	7 - 35i	1673	25 - 61i	1737	25 - 35i	1801	7 - 3i	1865	7 - 29i	1929	25 - 3i	1993	25 - 29i
1546	5 - 63i	1610	5 - 33i	1674	27 - 63i	1738	27 - 33i	1802	5 - 1i	1866	5 - 31i	1930	27 - 1i	1994	27 - 31i
1547	5 - 61i	1611	5 - 35i	1675	27 - 61i	1739	27 - 35i	1803	5 - 3i	1867	5 - 29i	1931	27 - 3i	1995	27 - 29i
1548	7 - 57i	1612	7 - 39i	1676	25 - 57i	1740	25 - 39i	1804	7 - 7i	1868	7 - 25i	1932	25 - 7i	1996	25 - 25i
1549	7 - 59i	1613	7 - 37i	1677	25 - 59i	1741	25 - 37i	1805	7 - 5i	1869	7 - 27i	1933	25 - 5i	1997	25 - 27i
1550	5 - 57i	1614	5 - 39i	1678	27 - 57i	1742	27 - 39i	1806	5 - 7i	1870	5 - 25i	1934	27 - 7i	1998	27 - 25i
1551	5 - 59i	1615	5 - 37i	1679	27 - 59i	1743	27 - 37i	1807	5 - 5i	1871	5 - 27i	1935	27 - 5i	1999	27 - 27i
1552	1 - 49i	1616	1 - 47i	1680	31 - 49i	1744	31 - 47i	1808	1 - 15i	1872	1 - 17i	1936	31 - 15i	2000	31 - 17i
1553	1 - 51i	1617	1 - 45i	1681	31 - 51i	1745	31 - 45i	1809	1 - 13i	1873	1 - 19i	1937	31 - 13i	2001	31 - 19i
1554	3 - 49i	1618	3 - 47i	1682	29 - 49i	1746	29 - 47i	1810	3 - 15i	1874	3 - 17i	1938	29 - 15i	2002	29 - 17i
1555	3 - 51i	1619	3 - 45i	1683	29 - 51i	1747	29 - 45i	1811	3 - 13i	1875	3 - 19i	1939	29 - 13i	2003	29 - 19i
1556	1 - 55i	1620	1 - 41i	1684	31 - 55i	1748	31 - 41i	1812	1 - 9i	1876	1 - 23i	1940	31 - 9i	2004	31 - 23i
1557	1 - 53i	1621	1 - 43i	1685	31 - 53i	1749	31 - 43i	1813	1 - 11i	1877	1 - 21i	1941	31 - 11i	2005	31 - 21i
1558	3 - 55i	1622	3 - 41i	1686	29 - 55i	1750	29 - 41i	1814	3 - 9i	1878	3 - 23i	1942	29 - 9i	2006	29 - 23i
1559	3 - 53i	1623	3 - 43i	1687	29 - 53i	1751	29 - 43i	1815	3 - 11i	1879	3 - 21i	1943	29 - 11i	2007	29 - 21i
1560	7 - 49i	1624	7 - 47i	1688	25 - 49i	1752	25 - 47i	1816	7 - 15i	1880	7 - 17i	1944	25 - 15i	2008	25 - 17i
1561	7 - 51i	1625	7 - 45i	1689	25 - 51i	1753	25 - 45i	1817	7 - 13i	1881	7 - 19i	1945	25 - 13i	2009	25 - 19i
1562	5 - 49i	1626	5 - 47i	1690	27 - 49i	1754	27 - 47i	1818	5 - 15i	1882	5 - 17i	1946	27 - 15i	2010	27 - 17i
1563	5 - 51i	1627	5 - 45i	1691	27 - 51i	1755	27 - 45i	1819	5 - 13i	1883	5 - 19i	1947	27 - 13i	2011	27 - 19i
1564	7 - 55i	1628	7 - 41i	1692	25 - 55i	1756	25 - 41i	1820	7 - 9i	1884	7 - 23i	1948	25 - 9i	2012	25 - 23i
1565	7 - 53i	1629	7 - 43i	1693	25 - 53i	1757	25 - 43i	1821	7 - 11i	1885	7 - 21i	1949	25 - 11i	2013	25 - 21i
1566	5 - 55i	1630	5 - 41i	1694	27 - 55i	1758	27 - 41i	1822	5 - 9i	1886	5 - 23i	1950	27 - 9i	2014	27 - 23i
1567	5 - 53i	1631	5 - 43i	1695	27 - 53i	1759	27 - 43i	1823	5 - 11i	1887	5 - 21i	1951	27 - 11i	2015	27 - 21i
1568	15 - 63i	1632	15 - 33i	1696	17 - 63i	1760	17 - 33i	1824	15 - 1i	1888	15 - 31i	1952	17 - 1i	2016	17 - 31i
1569	15 - 61i	1633	15 - 35i	1697	17 - 61i	1761	17 - 35i	1825	15 - 3i	1889	15 - 29i	1953	17 - 3i	2017	17 - 29i
1570	13 - 63i	1634	13 - 33i	1698	19 - 63i	1762	19 - 33i	1826	13 - 1i	1890	13 - 31i	1954	19 - 1i	2018	19 - 31i

FIG. 23

1571	13 - 61i	1635	13 - 35i	1699	19 - 61i	1763	19 - 35i	1827	13 - 3i	1891	13 - 29i	1955	19 - 3i	2019	19 - 29i
1572	15 - 57i	1636	15 - 39i	1700	17 - 57i	1764	17 - 39i	1828	15 - 7i	1892	15 - 25i	1956	17 - 7i	2020	17 - 25i
1573	15 - 59i	1637	15 - 37i	1701	17 - 59i	1765	17 - 37i	1829	15 - 5i	1893	15 - 27i	1957	17 - 5i	2021	17 - 27i
1574	13 - 57i	1638	13 - 39i	1702	19 - 57i	1766	19 - 39i	1830	13 - 7i	1894	13 - 25i	1958	19 - 7i	2022	19 - 25i
1575	13 - 59i	1639	13 - 37i	1703	19 - 59i	1767	19 - 37i	1831	13 - 5i	1895	13 - 27i	1959	19 - 5i	2023	19 - 27i
1576	9 - 63i	1640	9 - 33i	1704	23 - 63i	1768	23 - 33i	1832	9 - 1i	1896	9 - 31i	1960	23 - 1i	2024	23 - 31i
1577	9 - 61i	1641	9 - 35i	1705	23 - 61i	1769	23 - 35i	1833	9 - 3i	1897	9 - 29i	1961	23 - 3i	2025	23 - 29i
1578	11 - 63i	1642	11 - 33i	1706	21 - 63i	1770	21 - 33i	1834	11 - 1i	1898	11 - 31i	1962	21 - 1i	2026	21 - 31i
1579	11 - 61i	1643	11 - 35i	1707	21 - 61i	1771	21 - 35i	1835	11 - 3i	1899	11 - 29i	1963	21 - 3i	2027	21 - 29i
1580	9 - 57i	1644	9 - 39i	1708	23 - 57i	1772	23 - 39i	1836	9 - 7i	1900	9 - 25i	1964	23 - 7i	2028	23 - 25i
1581	9 - 59i	1645	9 - 37i	1709	23 - 59i	1773	23 - 37i	1837	9 - 5i	1901	9 - 27i	1965	23 - 5i	2029	23 - 27i
1582	11 - 57i	1646	11 - 39i	1710	21 - 57i	1774	21 - 39i	1838	11 - 7i	1902	11 - 25i	1966	21 - 7i	2030	21 - 25i
1583	11 - 59i	1647	11 - 37i	1711	21 - 59i	1775	21 - 37i	1839	11 - 5i	1903	11 - 27i	1967	21 - 5i	2031	21 - 27i
1584	15 - 49i	1648	15 - 47i	1712	17 - 49i	1776	17 - 47i	1840	15 - 15i	1904	15 - 17i	1968	17 - 15i	2032	17 - 17i
1585	15 - 51i	1649	15 - 45i	1713	17 - 51i	1777	17 - 45i	1841	15 - 13i	1905	15 - 19i	1969	17 - 13i	2033	17 - 19i
1586	13 - 49i	1650	13 - 47i	1714	19 - 49i	1778	19 - 47i	1842	13 - 15i	1906	13 - 17i	1970	19 - 15i	2034	19 - 17i
1587	13 - 51i	1651	13 - 45i	1715	19 - 51i	1779	19 - 45i	1843	13 - 13i	1907	13 - 19i	1971	19 - 13i	2035	19 - 19i
1588	15 - 55i	1652	15 - 41i	1716	17 - 55i	1780	17 - 41i	1844	15 - 9i	1908	15 - 23i	1972	17 - 9i	2036	17 - 23i
1589	15 - 53i	1653	15 - 43i	1717	17 - 53i	1781	17 - 43i	1845	15 - 11i	1909	15 - 21i	1973	17 - 11i	2037	17 - 21i
1590	13 - 55i	1654	13 - 41i	1718	19 - 55i	1782	19 - 41i	1846	13 - 9i	1910	13 - 23i	1974	19 - 9i	2038	19 - 23i
1591	13 - 53i	1655	13 - 43i	1719	19 - 53i	1783	19 - 43i	1847	13 - 11i	1911	13 - 21i	1975	19 - 11i	2039	19 - 21i
1592	9 - 49i	1656	9 - 47i	1720	23 - 49i	1784	23 - 47i	1848	9 - 15i	1912	9 - 17i	1976	23 - 15i	2040	23 - 17i
1593	9 - 51i	1657	9 - 45i	1721	23 - 51i	1785	23 - 45i	1849	9 - 13i	1913	9 - 19i	1977	23 - 13i	2041	23 - 19i
1594	11 - 49i	1658	11 - 47i	1722	21 - 49i	1786	21 - 47i	1850	11 - 15i	1914	11 - 17i	1978	21 - 15i	2042	21 - 17i
1595	11 - 51i	1659	11 - 45i	1723	21 - 51i	1787	21 - 45i	1851	11 - 13i	1915	11 - 19i	1979	21 - 13i	2043	21 - 19i
1596	9 - 55i	1660	9 - 41i	1724	23 - 55i	1788	23 - 41i	1852	9 - 9i	1916	9 - 23i	1980	23 - 9i	2044	23 - 23i
1597	9 - 53i	1661	9 - 43i	1725	23 - 53i	1789	23 - 43i	1853	9 - 11i	1917	9 - 21i	1981	23 - 11i	2045	23 - 21i
1598	11 - 55i	1662	11 - 41i	1726	21 - 55i	1790	21 - 41i	1854	11 - 9i	1918	11 - 23i	1982	21 - 9i	2046	21 - 23i
1599	11 - 53i	1663	11 - 43i	1727	21 - 53i	1791	21 - 43i	1855	11 - 11i	1919	11 - 21i	1983	21 - 11i	2047	21 - 21i

FIG. 24

Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter
2048	-1 + 65i	2112	-63 + 33i	2176	-33 + 63i	2240	-33 + 33i	2304	-63 + 1i	2368	-63 + 31i	2432	-33 + 1i	2496	-33 + 31i
2049	-65 + 3i	2113	-65 + 29i	2177	-33 + 61i	2241	-33 + 35i	2305	-63 + 3i	2369	-63 + 29i	2433	-33 + 3i	2497	-33 + 29i
2050	-3 + 65i	2114	-61 + 33i	2178	-29 + 65i	2242	-35 + 33i	2306	-61 + 1i	2370	-61 + 31i	2434	-35 + 1i	2498	-35 + 31i
2051	-3 + 67i	2115	-61 + 35i	2179	-35 + 61i	2243	-35 + 35i	2307	-61 + 3i	2371	-61 + 29i	2435	-35 + 3i	2499	-35 + 29i
2052	-65 + 7i	2116	-65 + 25i	2180	-33 + 57i	2244	-33 + 39i	2308	-63 + 7i	2372	-63 + 25i	2436	-33 + 7i	2500	-33 + 25i
2053	-65 + 5i	2117	-65 + 27i	2181	-33 + 59i	2245	-33 + 37i	2309	-63 + 5i	2373	-63 + 27i	2437	-33 + 5i	2501	-33 + 27i
2054	-67 + 7i	2118	-67 + 25i	2182	-35 + 57i	2246	-35 + 39i	2310	-61 + 7i	2374	-61 + 25i	2438	-35 + 7i	2502	-35 + 25i
2055	-67 + 5i	2119	-61 + 37i	2183	-35 + 59i	2247	-35 + 37i	2311	-61 + 5i	2375	-61 + 27i	2439	-35 + 5i	2503	-35 + 27i
2056	-7 + 65i	2120	-57 + 33i	2184	-25 + 65i	2248	-39 + 33i	2312	-57 + 1i	2376	-57 + 31i	2440	-39 + 1i	2504	-39 + 31i
2057	-7 + 67i	2121	-57 + 35i	2185	-25 + 67i	2249	-39 + 35i	2313	-57 + 3i	2377	-57 + 29i	2441	-39 + 3i	2505	-39 + 29i
2058	-5 + 65i	2122	-59 + 33i	2186	-27 + 65i	2250	-37 + 33i	2314	-59 + 1i	2378	-59 + 31i	2442	-37 + 1i	2506	-37 + 31i
2059	-5 + 67i	2123	-59 + 35i	2187	-37 + 61i	2251	-37 + 35i	2315	-59 + 3i	2379	-59 + 29i	2443	-37 + 3i	2507	-37 + 29i
2060	-7 + 71i	2124	-57 + 39i	2188	-39 + 57i	2252	-39 + 39i	2316	-57 + 7i	2380	-57 + 25i	2444	-39 + 7i	2508	-39 + 25i
2061	-7 + 69i	2125	-57 + 37i	2189	-39 + 59i	2253	-39 + 37i	2317	-57 + 5i	2381	-57 + 27i	2445	-39 + 5i	2509	-39 + 27i
2062	-69 + 7i	2126	-59 + 39i	2190	-37 + 57i	2254	-37 + 39i	2318	-59 + 7i	2382	-59 + 25i	2446	-37 + 7i	2510	-37 + 25i
2063	-5 + 69i	2127	-59 + 37i	2191	-37 + 59i	2255	-37 + 37i	2319	-59 + 5i	2383	-59 + 27i	2447	-37 + 5i	2511	-37 + 27i
2064	-65 + 15i	2128	-65 + 17i	2192	-33 + 49i	2256	-33 + 47i	2320	-63 + 15i	2384	-63 + 17i	2448	-33 + 15i	2512	-33 + 17i
2065	-65 + 13i	2129	-65 + 19i	2193	-33 + 51i	2257	-33 + 45i	2321	-63 + 13i	2385	-63 + 19i	2449	-33 + 13i	2513	-33 + 19i
2066	-67 + 15i	2130	-67 + 17i	2194	-35 + 49i	2258	-35 + 47i	2322	-61 + 15i	2386	-61 + 17i	2450	-35 + 15i	2514	-35 + 17i
2067	-67 + 13i	2131	-67 + 19i	2195	-35 + 51i	2259	-35 + 45i	2323	-61 + 13i	2387	-61 + 19i	2451	-35 + 13i	2515	-35 + 19i
2068	-65 + 9i	2132	-65 + 23i	2196	-33 + 55i	2260	-33 + 41i	2324	-63 + 9i	2388	-63 + 23i	2452	-33 + 9i	2516	-33 + 23i
2069	-65 + 11i	2133	-65 + 21i	2197	-33 + 53i	2261	-33 + 43i	2325	-63 + 11i	2389	-63 + 21i	2453	-33 + 11i	2517	-33 + 21i
2070	-67 + 9i	2134	-67 + 23i	2198	-35 + 55i	2262	-35 + 41i	2326	-61 + 9i	2390	-61 + 23i	2454	-35 + 9i	2518	-35 + 23i
2071	-67 + 11i	2135	-67 + 21i	2199	-35 + 53i	2263	-35 + 43i	2327	-61 + 11i	2391	-61 + 21i	2455	-35 + 11i	2519	-35 + 21i
2072	-71 + 15i	2136	-71 + 17i	2200	-39 + 49i	2264	-39 + 47i	2328	-57 + 15i	2392	-57 + 17i	2456	-39 + 15i	2520	-39 + 17i
2073	-71 + 13i	2137	-57 + 45i	2201	-39 + 51i	2265	-39 + 45i	2329	-57 + 13i	2393	-57 + 19i	2457	-39 + 13i	2521	-39 + 19i
2074	-69 + 15i	2138	-69 + 17i	2202	-37 + 49i	2266	-37 + 47i	2330	-59 + 15i	2394	-59 + 17i	2458	-37 + 15i	2522	-37 + 17i
2075	-69 + 13i	2139	-69 + 19i	2203	-37 + 51i	2267	-37 + 45i	2331	-59 + 13i	2395	-59 + 19i	2459	-37 + 13i	2523	-37 + 19i
2076	-71 + 9i	2140	-57 + 41i	2204	-39 + 55i	2268	-39 + 41i	2332	-57 + 9i	2396	-57 + 23i	2460	-39 + 9i	2524	-39 + 23i
2077	-71 + 11i	2141	-57 + 43i	2205	-39 + 53i	2269	-39 + 43i	2333	-57 + 11i	2397	-57 + 21i	2461	-39 + 11i	2525	-39 + 21i
2078	-69 + 9i	2142	-59 + 41i	2206	-37 + 55i	2270	-37 + 41i	2334	-59 + 9i	2398	-59 + 23i	2462	-37 + 9i	2526	-37 + 23i
2079	-69 + 11i	2143	-69 + 21i	2207	-37 + 53i	2271	-37 + 43i	2335	-59 + 11i	2399	-59 + 21i	2463	-37 + 11i	2527	-37 + 21i
2080	-15 + 65i	2144	-49 + 33i	2208	-17 + 65i	2272	-47 + 33i	2336	-49 + 1i	2400	-49 + 31i	2464	-47 + 1i	2528	-47 + 31i

FIG. 25

2081	-15 + 67i	2145	-49 + 35i	2209	-17 + 67i	2273	-47 + 35i	2337	-49 + 3i	2401	-49 + 29i	2465	-47 + 3i	2529	-47 + 29i
2082	-13 + 65i	2146	-51 + 33i	2210	-19 + 65i	2274	-45 + 33i	2338	-51 + 1i	2402	-51 + 31i	2466	-45 + 1i	2530	-45 + 31i
2083	-13 + 67i	2147	-51 + 35i	2211	-19 + 67i	2275	-45 + 35i	2339	-51 + 3i	2403	-51 + 29i	2467	-45 + 3i	2531	-45 + 29i
2084	-15 + 71i	2148	-49 + 39i	2212	-17 + 71i	2276	-47 + 39i	2340	-49 + 7i	2404	-49 + 25i	2468	-47 + 7i	2532	-47 + 25i
2085	-15 + 69i	2149	-49 + 37i	2213	-17 + 69i	2277	-47 + 37i	2341	-49 + 5i	2405	-49 + 27i	2469	-47 + 5i	2533	-47 + 27i
2086	-13 + 71i	2150	-51 + 39i	2214	-45 + 57i	2278	-45 + 39i	2342	-51 + 7i	2406	-51 + 25i	2470	-45 + 7i	2534	-45 + 25i
2087	-13 + 69i	2151	-51 + 37i	2215	-19 + 69i	2279	-45 + 37i	2343	-51 + 5i	2407	-51 + 27i	2471	-45 + 5i	2535	-45 + 27i
2088	-9 + 65i	2152	-55 + 33i	2216	-23 + 65i	2280	-41 + 33i	2344	-55 + 1i	2408	-55 + 31i	2472	-41 + 1i	2536	-41 + 31i
2089	-9 + 67i	2153	-55 + 35i	2217	-23 + 67i	2281	-41 + 35i	2345	-55 + 3i	2409	-55 + 29i	2473	-41 + 3i	2537	-41 + 29i
2090	-11 + 65i	2154	-53 + 33i	2218	-21 + 65i	2282	-43 + 33i	2346	-53 + 1i	2410	-53 + 31i	2474	-43 + 1i	2538	-43 + 31i
2091	-11 + 67i	2155	-53 + 35i	2219	-21 + 67i	2283	-43 + 35i	2347	-53 + 3i	2411	-53 + 29i	2475	-43 + 3i	2539	-43 + 29i
2092	-9 + 71i	2156	-55 + 39i	2220	-41 + 57i	2284	-41 + 39i	2348	-55 + 7i	2412	-55 + 25i	2476	-41 + 7i	2540	-41 + 25i
2093	-9 + 69i	2157	-55 + 37i	2221	-41 + 59i	2285	-41 + 37i	2349	-55 + 5i	2413	-55 + 27i	2477	-41 + 5i	2541	-41 + 27i
2094	-11 + 71i	2158	-53 + 39i	2222	-43 + 57i	2286	-43 + 39i	2350	-53 + 7i	2414	-53 + 25i	2478	-43 + 7i	2542	-43 + 25i
2095	-11 + 69i	2159	-53 + 37i	2223	-21 + 69i	2287	-43 + 37i	2351	-53 + 5i	2415	-53 + 27i	2479	-43 + 5i	2543	-43 + 27i
2096	-49 + 49i	2160	-49 + 47i	2224	-47 + 49i	2288	-47 + 47i	2352	-49 + 15i	2416	-49 + 17i	2480	-47 + 15i	2544	-47 + 17i
2097	-49 + 51i	2161	-49 + 45i	2225	-47 + 51i	2289	-47 + 45i	2353	-49 + 13i	2417	-49 + 19i	2481	-47 + 13i	2545	-47 + 19i
2098	-51 + 49i	2162	-51 + 47i	2226	-45 + 49i	2290	-45 + 47i	2354	-51 + 15i	2418	-51 + 17i	2482	-45 + 15i	2546	-45 + 17i
2099	-51 + 51i	2163	-51 + 45i	2227	-45 + 51i	2291	-45 + 45i	2355	-51 + 13i	2419	-51 + 19i	2483	-45 + 13i	2547	-45 + 19i
2100	-49 + 55i	2164	-49 + 41i	2228	-47 + 55i	2292	-47 + 41i	2356	-49 + 9i	2420	-49 + 23i	2484	-47 + 9i	2548	-47 + 23i
2101	-49 + 53i	2165	-49 + 43i	2229	-47 + 53i	2293	-47 + 43i	2357	-49 + 11i	2421	-49 + 21i	2485	-47 + 11i	2549	-47 + 21i
2102	-13 + 73i	2166	-51 + 41i	2230	-45 + 55i	2294	-45 + 41i	2358	-51 + 9i	2422	-51 + 23i	2486	-45 + 9i	2550	-45 + 23i
2103	-51 + 53i	2167	-51 + 43i	2231	-45 + 53i	2295	-45 + 43i	2359	-51 + 11i	2423	-51 + 21i	2487	-45 + 11i	2551	-45 + 21i
2104	-55 + 49i	2168	-55 + 47i	2232	-41 + 49i	2296	-41 + 47i	2360	-55 + 15i	2424	-55 + 17i	2488	-41 + 15i	2552	-41 + 17i
2105	-73 + 13i	2169	-55 + 45i	2233	-41 + 51i	2297	-41 + 45i	2361	-55 + 13i	2425	-55 + 19i	2489	-41 + 13i	2553	-41 + 19i
2106	-53 + 49i	2170	-53 + 47i	2234	-43 + 49i	2298	-43 + 47i	2362	-53 + 15i	2426	-53 + 17i	2490	-43 + 15i	2554	-43 + 17i
2107	-53 + 51i	2171	-53 + 45i	2235	-43 + 51i	2299	-43 + 45i	2363	-53 + 13i	2427	-53 + 19i	2491	-43 + 13i	2555	-43 + 19i
2108	-9 + 73i	2172	-55 + 41i	2236	-41 + 55i	2300	-41 + 41i	2364	-55 + 9i	2428	-55 + 23i	2492	-41 + 9i	2556	-41 + 23i
2109	-73 + 11i	2173	-55 + 43i	2237	-41 + 53i	2301	-41 + 43i	2365	-55 + 11i	2429	-55 + 21i	2493	-41 + 11i	2557	-41 + 21i
2110	-11 + 73i	2174	-53 + 41i	2238	-43 + 55i	2302	-43 + 41i	2366	-53 + 9i	2430	-53 + 23i	2494	-43 + 9i	2558	-43 + 23i
2111	-53 + 53i	2175	-53 + 43i	2239	-43 + 53i	2303	-43 + 43i	2367	-53 + 11i	2431	-53 + 21i	2495	-43 + 11i	2559	-43 + 21i

FIG. 26

Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter
2560	-1 + 63i	2624	-1 + 33i	2688	-31 + 63i	2752	-31 + 33i	2816	-1 + 1i	2880	-1 + 31i	2944	-31 + 1i	3008	-31 + 31i
2561	-1 + 61i	2625	-1 + 35i	2689	-31 + 61i	2753	-31 + 35i	2817	-1 + 3i	2881	-1 + 29i	2945	-31 + 3i	3009	-31 + 29i
2562	-3 + 63i	2626	-3 + 33i	2690	-29 + 63i	2754	-29 + 33i	2818	-3 + 1i	2882	-3 + 31i	2946	-29 + 1i	3010	-29 + 31i
2563	-3 + 61i	2627	-3 + 35i	2691	-29 + 61i	2755	-29 + 35i	2819	-3 + 3i	2883	-3 + 29i	2947	-29 + 3i	3011	-29 + 29i
2564	-1 + 57i	2628	-1 + 39i	2692	-31 + 57i	2756	-31 + 39i	2820	-1 + 7i	2884	-1 + 25i	2948	-31 + 7i	3012	-31 + 25i
2565	-1 + 59i	2629	-1 + 37i	2693	-31 + 59i	2757	-31 + 37i	2821	-1 + 5i	2885	-1 + 27i	2949	-31 + 5i	3013	-31 + 27i
2566	-3 + 57i	2630	-3 + 39i	2694	-29 + 57i	2758	-29 + 39i	2822	-3 + 7i	2886	-3 + 25i	2950	-29 + 7i	3014	-29 + 25i
2567	-3 + 59i	2631	-3 + 37i	2695	-29 + 59i	2759	-29 + 37i	2823	-3 + 5i	2887	-3 + 27i	2951	-29 + 5i	3015	-29 + 27i
2568	-7 + 63i	2632	-7 + 33i	2696	-25 + 63i	2760	-25 + 33i	2824	-7 + 1i	2888	-7 + 31i	2952	-25 + 1i	3016	-25 + 31i
2569	-7 + 61i	2633	-7 + 35i	2697	-25 + 61i	2761	-25 + 35i	2825	-7 + 3i	2889	-7 + 29i	2953	-25 + 3i	3017	-25 + 29i
2570	-5 + 63i	2634	-5 + 33i	2698	-27 + 63i	2762	-27 + 33i	2826	-5 + 1i	2890	-5 + 31i	2954	-27 + 1i	3018	-27 + 31i
2571	-5 + 61i	2635	-5 + 35i	2699	-27 + 61i	2763	-27 + 35i	2827	-5 + 3i	2891	-5 + 29i	2955	-27 + 3i	3019	-27 + 29i
2572	-7 + 57i	2636	-7 + 39i	2700	-25 + 57i	2764	-25 + 39i	2828	-7 + 7i	2892	-7 + 25i	2956	-25 + 7i	3020	-25 + 25i
2573	-7 + 59i	2637	-7 + 37i	2701	-25 + 59i	2765	-25 + 37i	2829	-7 + 5i	2893	-7 + 27i	2957	-25 + 5i	3021	-25 + 27i
2574	-5 + 57i	2638	-5 + 39i	2702	-27 + 57i	2766	-27 + 39i	2830	-5 + 7i	2894	-5 + 25i	2958	-27 + 7i	3022	-27 + 25i
2575	-5 + 59i	2639	-5 + 37i	2703	-27 + 59i	2767	-27 + 37i	2831	-5 + 5i	2895	-5 + 27i	2959	-27 + 5i	3023	-27 + 27i
2576	-1 + 49i	2640	-1 + 47i	2704	-31 + 49i	2768	-31 + 47i	2832	-1 + 15i	2896	-1 + 17i	2960	-31 + 15i	3024	-31 + 17i
2577	-1 + 51i	2641	-1 + 45i	2705	-31 + 51i	2769	-31 + 45i	2833	-1 + 13i	2897	-1 + 19i	2961	-31 + 13i	3025	-31 + 19i
2578	-3 + 49i	2642	-3 + 47i	2706	-29 + 49i	2770	-29 + 47i	2834	-3 + 15i	2898	-3 + 17i	2962	-29 + 15i	3026	-29 + 17i
2579	-3 + 51i	2643	-3 + 45i	2707	-29 + 51i	2771	-29 + 45i	2835	-3 + 13i	2899	-3 + 19i	2963	-29 + 13i	3027	-29 + 19i
2580	-1 + 55i	2644	-1 + 41i	2708	-31 + 55i	2772	-31 + 41i	2836	-1 + 9i	2900	-1 + 23i	2964	-31 + 9i	3028	-31 + 23i
2581	-1 + 53i	2645	-1 + 43i	2709	-31 + 53i	2773	-31 + 43i	2837	-1 + 11i	2901	-1 + 21i	2965	-31 + 11i	3029	-31 + 21i
2582	-3 + 55i	2646	-3 + 41i	2710	-29 + 55i	2774	-29 + 41i	2838	-3 + 9i	2902	-3 + 23i	2966	-29 + 9i	3030	-29 + 23i
2583	-3 + 53i	2647	-3 + 43i	2711	-29 + 53i	2775	-29 + 43i	2839	-3 + 11i	2903	-3 + 21i	2967	-29 + 11i	3031	-29 + 21i
2584	-7 + 49i	2648	-7 + 47i	2712	-25 + 49i	2776	-25 + 47i	2840	-7 + 15i	2904	-7 + 17i	2968	-25 + 15i	3032	-25 + 17i
2585	-7 + 51i	2649	-7 + 45i	2713	-25 + 51i	2777	-25 + 45i	2841	-7 + 13i	2905	-7 + 19i	2969	-25 + 13i	3033	-25 + 19i
2586	-5 + 49i	2650	-5 + 47i	2714	-27 + 49i	2778	-27 + 47i	2842	-5 + 15i	2906	-5 + 17i	2970	-27 + 15i	3034	-27 + 17i
2587	-5 + 51i	2651	-5 + 45i	2715	-27 + 51i	2779	-27 + 45i	2843	-5 + 13i	2907	-5 + 19i	2971	-27 + 13i	3035	-27 + 19i
2588	-7 + 55i	2652	-7 + 41i	2716	-25 + 55i	2780	-25 + 41i	2844	-7 + 9i	2908	-7 + 23i	2972	-25 + 9i	3036	-25 + 23i
2589	-7 + 53i	2653	-7 + 43i	2717	-25 + 53i	2781	-25 + 43i	2845	-7 + 11i	2909	-7 + 21i	2973	-25 + 11i	3037	-25 + 21i
2590	-5 + 55i	2654	-5 + 41i	2718	-27 + 55i	2782	-27 + 41i	2846	-5 + 9i	2910	-5 + 23i	2974	-27 + 9i	3038	-27 + 23i

FIG. 27

2591	-5 + 53i	2655	-5 + 43i	2719	-27 + 53i	2783	-27 + 43i	2847	-5 + 11i	2911	-5 + 21i	2975	-27 + 11i	3039	-27 + 21i
2592	-15 + 63i	2656	-15 + 33i	2720	-17 + 63i	2784	-17 + 33i	2848	-15 + 1i	2912	-15 + 31i	2976	-17 + 1i	3040	-17 + 31i
2593	-15 + 61i	2657	-15 + 35i	2721	-17 + 61i	2785	-17 + 35i	2849	-15 + 3i	2913	-15 + 29i	2977	-17 + 3i	3041	-17 + 29i
2594	-13 + 63i	2658	-13 + 33i	2722	-19 + 63i	2786	-19 + 33i	2850	-13 + 1i	2914	-13 + 31i	2978	-19 + 1i	3042	-19 + 31i
2595	-13 + 61i	2659	-13 + 35i	2723	-19 + 61i	2787	-19 + 35i	2851	-13 + 3i	2915	-13 + 29i	2979	-19 + 3i	3043	-19 + 29i
2596	-15 + 57i	2660	-15 + 39i	2724	-17 + 57i	2788	-17 + 39i	2852	-15 + 7i	2916	-15 + 25i	2980	-17 + 7i	3044	-17 + 25i
2597	-15 + 59i	2661	-15 + 37i	2725	-17 + 59i	2789	-17 + 37i	2853	-15 + 5i	2917	-15 + 27i	2981	-17 + 5i	3045	-17 + 27i
2598	-13 + 57i	2662	-13 + 39i	2726	-19 + 57i	2790	-19 + 39i	2854	-13 + 7i	2918	-13 + 25i	2982	-19 + 7i	3046	-19 + 25i
2599	-13 + 59i	2663	-13 + 37i	2727	-19 + 59i	2791	-19 + 37i	2855	-13 + 5i	2919	-13 + 27i	2983	-19 + 5i	3047	-19 + 27i
2600	-9 + 63i	2664	-9 + 33i	2728	-23 + 63i	2792	-23 + 33i	2856	-9 + 1i	2920	-9 + 31i	2984	-23 + 1i	3048	-23 + 31i
2601	-9 + 61i	2665	-9 + 35i	2729	-23 + 61i	2793	-23 + 35i	2857	-9 + 3i	2921	-9 + 29i	2985	-23 + 3i	3049	-23 + 29i
2602	-11 + 63i	2666	-11 + 33i	2730	-21 + 63i	2794	-21 + 33i	2858	-11 + 1i	2922	-11 + 31i	2986	-21 + 1i	3050	-21 + 31i
2603	-11 + 61i	2667	-11 + 35i	2731	-21 + 61i	2795	-21 + 35i	2859	-11 + 3i	2923	-11 + 29i	2987	-21 + 3i	3051	-21 + 29i
2604	-9 + 57i	2668	-9 + 39i	2732	-23 + 57i	2796	-23 + 39i	2860	-9 + 7i	2924	-9 + 25i	2988	-23 + 7i	3052	-23 + 25i
2605	-9 + 59i	2669	-9 + 37i	2733	-23 + 59i	2797	-23 + 37i	2861	-9 + 5i	2925	-9 + 27i	2989	-23 + 5i	3053	-23 + 27i
2606	-11 + 57i	2670	-11 + 39i	2734	-21 + 57i	2798	-21 + 39i	2862	-11 + 7i	2926	-11 + 25i	2990	-21 + 7i	3054	-21 + 25i
2607	-11 + 59i	2671	-11 + 37i	2735	-21 + 59i	2799	-21 + 37i	2863	-11 + 5i	2927	-11 + 27i	2991	-21 + 5i	3055	-21 + 27i
2608	-15 + 49i	2672	-15 + 47i	2736	-17 + 49i	2800	-17 + 47i	2864	-15 + 15i	2928	-15 + 17i	2992	-17 + 15i	3056	-17 + 17i
2609	-15 + 51i	2673	-15 + 45i	2737	-17 + 51i	2801	-17 + 45i	2865	-15 + 13i	2929	-15 + 19i	2993	-17 + 13i	3057	-17 + 19i
2610	-13 + 49i	2674	-13 + 47i	2738	-19 + 49i	2802	-19 + 47i	2866	-13 + 15i	2930	-13 + 17i	2994	-19 + 15i	3058	-19 + 17i
2611	-13 + 51i	2675	-13 + 45i	2739	-19 + 51i	2803	-19 + 45i	2867	-13 + 13i	2931	-13 + 19i	2995	-19 + 13i	3059	-19 + 19i
2612	-15 + 55i	2676	-15 + 41i	2740	-17 + 55i	2804	-17 + 41i	2868	-15 + 9i	2932	-15 + 23i	2996	-17 + 9i	3060	-17 + 23i
2613	-15 + 53i	2677	-15 + 43i	2741	-17 + 53i	2805	-17 + 43i	2869	-15 + 11i	2933	-15 + 21i	2997	-17 + 11i	3061	-17 + 21i
2614	-13 + 55i	2678	-13 + 41i	2742	-19 + 55i	2806	-19 + 41i	2870	-13 + 9i	2934	-13 + 23i	2998	-19 + 9i	3062	-19 + 23i
2615	-13 + 53i	2679	-13 + 43i	2743	-19 + 53i	2807	-19 + 43i	2871	-13 + 11i	2935	-13 + 21i	2999	-19 + 11i	3063	-19 + 21i
2616	-9 + 49i	2680	-9 + 47i	2744	-23 + 49i	2808	-23 + 47i	2872	-9 + 15i	2936	-9 + 17i	3000	-23 + 15i	3064	-23 + 17i
2617	-9 + 51i	2681	-9 + 45i	2745	-23 + 51i	2809	-23 + 45i	2873	-9 + 13i	2937	-9 + 19i	3001	-23 + 13i	3065	-23 + 19i
2618	-11 + 49i	2682	-11 + 47i	2746	-21 + 49i	2810	-21 + 47i	2874	-11 + 15i	2938	-11 + 17i	3002	-21 + 15i	3066	-21 + 17i
2619	-11 + 51i	2683	-11 + 45i	2747	-21 + 51i	2811	-21 + 45i	2875	-11 + 13i	2939	-11 + 19i	3003	-21 + 13i	3067	-21 + 19i
2620	-9 + 55i	2684	-9 + 41i	2748	-23 + 55i	2812	-23 + 41i	2876	-9 + 9i	2940	-9 + 23i	3004	-23 + 9i	3068	-23 + 23i
2621	-9 + 53i	2685	-9 + 43i	2749	-23 + 53i	2813	-23 + 43i	2877	-9 + 11i	2941	-9 + 21i	3005	-23 + 11i	3069	-23 + 21i
2622	-11 + 55i	2686	-11 + 41i	2750	-21 + 55i	2814	-21 + 41i	2878	-11 + 9i	2942	-11 + 23i	3006	-21 + 9i	3070	-21 + 23i
2623	-11 + 53i	2687	-11 + 43i	2751	-21 + 53i	2815	-21 + 43i	2879	-11 + 11i	2943	-11 + 21i	3007	-21 + 11i	3071	-21 + 21i

FIG. 28

Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter
3072	-65 - 1i	3136	-63 - 33i	3200	-33 - 63i	3264	-33 - 33i	3328	-63 - 1i	3392	-63 - 31i	3456	-33 - 1i	3520	-33 - 31i
3073	-65 - 3i	3137	-65 - 29i	3201	-33 - 61i	3265	-33 - 35i	3329	-63 - 3i	3393	-63 - 29i	3457	-33 - 3i	3521	-33 - 29i
3074	-3 - 65i	3138	-61 - 33i	3202	-29 - 65i	3266	-35 - 33i	3330	-61 - 1i	3394	-61 - 31i	3458	-35 - 1i	3522	-35 - 31i
3075	-67 - 3i	3139	-61 - 35i	3203	-35 - 61i	3267	-35 - 35i	3331	-61 - 3i	3395	-61 - 29i	3459	-35 - 3i	3523	-35 - 29i
3076	-65 - 7i	3140	-65 - 25i	3204	-33 - 57i	3268	-33 - 39i	3332	-63 - 7i	3396	-63 - 25i	3460	-33 - 7i	3524	-33 - 25i
3077	-65 - 5i	3141	-65 - 27i	3205	-33 - 59i	3269	-33 - 37i	3333	-63 - 5i	3397	-63 - 27i	3461	-33 - 5i	3525	-33 - 27i
3078	-67 - 7i	3142	-67 - 25i	3206	-35 - 57i	3270	-35 - 39i	3334	-61 - 7i	3398	-61 - 25i	3462	-35 - 7i	3526	-35 - 25i
3079	-67 - 5i	3143	-61 - 37i	3207	-35 - 59i	3271	-35 - 37i	3335	-61 - 5i	3399	-61 - 27i	3463	-35 - 5i	3527	-35 - 27i
3080	-7 - 65i	3144	-57 - 33i	3208	-25 - 65i	3272	-39 - 33i	3336	-57 - 1i	3400	-57 - 31i	3464	-39 - 1i	3528	-39 - 31i
3081	-7 - 67i	3145	-57 - 35i	3209	-25 - 67i	3273	-39 - 35i	3337	-57 - 3i	3401	-57 - 29i	3465	-39 - 3i	3529	-39 - 29i
3082	-5 - 65i	3146	-59 - 33i	3210	-27 - 65i	3274	-37 - 33i	3338	-59 - 1i	3402	-59 - 31i	3466	-37 - 1i	3530	-37 - 31i
3083	-5 - 67i	3147	-59 - 35i	3211	-37 - 61i	3275	-37 - 35i	3339	-59 - 3i	3403	-59 - 29i	3467	-37 - 3i	3531	-37 - 29i
3084	-71 - 7i	3148	-57 - 39i	3212	-39 - 57i	3276	-39 - 39i	3340	-57 - 7i	3404	-57 - 25i	3468	-39 - 7i	3532	-39 - 25i
3085	-7 - 69i	3149	-57 - 37i	3213	-39 - 59i	3277	-39 - 37i	3341	-57 - 5i	3405	-57 - 27i	3469	-39 - 5i	3533	-39 - 27i
3086	-69 - 7i	3150	-59 - 39i	3214	-37 - 57i	3278	-37 - 39i	3342	-59 - 7i	3406	-59 - 25i	3470	-37 - 7i	3534	-37 - 25i
3087	-69 - 5i	3151	-59 - 37i	3215	-37 - 59i	3279	-37 - 37i	3343	-59 - 5i	3407	-59 - 27i	3471	-37 - 5i	3535	-37 - 27i
3088	-65 - 15i	3152	-65 - 17i	3216	-33 - 49i	3280	-33 - 47i	3344	-63 - 15i	3408	-63 - 17i	3472	-33 - 15i	3536	-33 - 17i
3089	-65 - 13i	3153	-65 - 19i	3217	-33 - 51i	3281	-33 - 45i	3345	-63 - 13i	3409	-63 - 19i	3473	-33 - 13i	3537	-33 - 19i
3090	-67 - 15i	3154	-67 - 17i	3218	-35 - 49i	3282	-35 - 47i	3346	-61 - 15i	3410	-61 - 17i	3474	-35 - 15i	3538	-35 - 17i
3091	-67 - 13i	3155	-67 - 19i	3219	-35 - 51i	3283	-35 - 45i	3347	-61 - 13i	3411	-61 - 19i	3475	-35 - 13i	3539	-35 - 19i
3092	-65 - 9i	3156	-65 - 23i	3220	-33 - 55i	3284	-33 - 41i	3348	-63 - 9i	3412	-63 - 23i	3476	-33 - 9i	3540	-33 - 23i
3093	-65 - 11i	3157	-65 - 21i	3221	-33 - 53i	3285	-33 - 43i	3349	-63 - 11i	3413	-63 - 21i	3477	-33 - 11i	3541	-33 - 21i
3094	-67 - 9i	3158	-67 - 23i	3222	-35 - 55i	3286	-35 - 41i	3350	-61 - 9i	3414	-61 - 23i	3478	-35 - 9i	3542	-35 - 23i
3095	-67 - 11i	3159	-67 - 21i	3223	-35 - 53i	3287	-35 - 43i	3351	-61 - 11i	3415	-61 - 21i	3479	-35 - 11i	3543	-35 - 21i
3096	-71 - 15i	3160	-71 - 17i	3224	-39 - 49i	3288	-39 - 47i	3352	-57 - 15i	3416	-57 - 17i	3480	-39 - 15i	3544	-39 - 17i
3097	-71 - 13i	3161	-57 - 45i	3225	-39 - 51i	3289	-39 - 45i	3353	-57 - 13i	3417	-57 - 19i	3481	-39 - 13i	3545	-39 - 19i
3098	-69 - 15i	3162	-69 - 17i	3226	-37 - 49i	3290	-37 - 47i	3354	-59 - 15i	3418	-59 - 17i	3482	-37 - 15i	3546	-37 - 17i
3099	-69 - 13i	3163	-69 - 19i	3227	-37 - 51i	3291	-37 - 45i	3355	-59 - 13i	3419	-59 - 19i	3483	-37 - 13i	3547	-37 - 19i
3100	-71 - 9i	3164	-57 - 41i	3228	-39 - 55i	3292	-39 - 41i	3356	-57 - 9i	3420	-57 - 23i	3484	-39 - 9i	3548	-39 - 23i

FIG. 29

3101	-71 - 11i	3165	-57 - 43i	3229	-39 - 53i	3293	-39 - 43i	3357	-57 - 11i	3421	-57 - 21i	3485	-39 - 11i	3549	-39 - 21i
3102	-69 - 9i	3166	-59 - 41i	3230	-37 - 55i	3294	-37 - 41i	3358	-59 - 9i	3422	-59 - 23i	3486	-37 - 9i	3550	-37 - 23i
3103	-69 - 11i	3167	-69 - 21i	3231	-37 - 53i	3295	-37 - 43i	3359	-59 - 11i	3423	-59 - 21i	3487	-37 - 11i	3551	-37 - 21i
3104	-15 - 65i	3168	-49 - 33i	3232	-17 - 65i	3296	-47 - 33i	3360	-49 - 1i	3424	-49 - 31i	3488	-47 - 1i	3552	-47 - 31i
3105	-15 - 67i	3169	-49 - 35i	3233	-17 - 67i	3297	-47 - 35i	3361	-49 - 3i	3425	-49 - 29i	3489	-47 - 3i	3553	-47 - 29i
3106	-13 - 65i	3170	-51 - 33i	3234	-19 - 65i	3298	-45 - 33i	3362	-51 - 1i	3426	-51 - 31i	3490	-45 - 1i	3554	-45 - 31i
3107	-13 - 67i	3171	-51 - 35i	3235	-19 - 67i	3299	-45 - 35i	3363	-51 - 3i	3427	-51 - 29i	3491	-45 - 3i	3555	-45 - 29i
3108	-15 - 71i	3172	-49 - 39i	3236	-17 - 71i	3300	-47 - 39i	3364	-49 - 7i	3428	-49 - 25i	3492	-47 - 7i	3556	-47 - 25i
3109	-15 - 69i	3173	-49 - 37i	3237	-17 - 69i	3301	-47 - 37i	3365	-49 - 5i	3429	-49 - 27i	3493	-47 - 5i	3557	-47 - 27i
3110	-13 - 71i	3174	-51 - 39i	3238	-45 - 57i	3302	-45 - 39i	3366	-51 - 7i	3430	-51 - 25i	3494	-45 - 7i	3558	-45 - 25i
3111	-13 - 69i	3175	-51 - 37i	3239	-19 - 69i	3303	-45 - 37i	3367	-51 - 5i	3431	-51 - 27i	3495	-45 - 5i	3559	-45 - 27i
3112	-9 - 65i	3176	-55 - 33i	3240	-23 - 65i	3304	-41 - 33i	3368	-55 - 1i	3432	-55 - 31i	3496	-41 - 1i	3560	-41 - 31i
3113	-9 - 67i	3177	-55 - 35i	3241	-23 - 67i	3305	-41 - 35i	3369	-55 - 3i	3433	-55 - 29i	3497	-41 - 3i	3561	-41 - 29i
3114	-11 - 65i	3178	-53 - 33i	3242	-21 - 65i	3306	-43 - 33i	3370	-53 - 1i	3434	-53 - 31i	3498	-43 - 1i	3562	-43 - 31i
3115	-11 - 67i	3179	-53 - 35i	3243	-21 - 67i	3307	-43 - 35i	3371	-53 - 3i	3435	-53 - 29i	3499	-43 - 3i	3563	-43 - 29i
3116	-9 - 71i	3180	-55 - 39i	3244	-41 - 57i	3308	-41 - 39i	3372	-55 - 7i	3436	-55 - 25i	3500	-41 - 7i	3564	-41 - 25i
3117	-9 - 69i	3181	-55 - 37i	3245	-41 - 59i	3309	-41 - 37i	3373	-55 - 5i	3437	-55 - 27i	3501	-41 - 5i	3565	-41 - 27i
3118	-11 - 71i	3182	-53 - 39i	3246	-43 - 57i	3310	-43 - 39i	3374	-53 - 7i	3438	-53 - 25i	3502	-43 - 7i	3566	-43 - 25i
3119	-11 - 69i	3183	-53 - 37i	3247	-21 - 69i	3311	-43 - 37i	3375	-53 - 5i	3439	-53 - 27i	3503	-43 - 5i	3567	-43 - 27i
3120	-49 - 49i	3184	-49 - 47i	3248	-47 - 49i	3312	-47 - 47i	3376	-49 - 15i	3440	-49 - 17i	3504	-47 - 15i	3568	-47 - 17i
3121	-49 - 51i	3185	-49 - 45i	3249	-47 - 51i	3313	-47 - 45i	3377	-49 - 13i	3441	-49 - 19i	3505	-47 - 13i	3569	-47 - 19i
3122	-51 - 49i	3186	-51 - 47i	3250	-45 - 49i	3314	-45 - 47i	3378	-51 - 15i	3442	-51 - 17i	3506	-45 - 15i	3570	-45 - 17i
3123	-51 - 51i	3187	-51 - 45i	3251	-45 - 51i	3315	-45 - 45i	3379	-51 - 13i	3443	-51 - 19i	3507	-45 - 13i	3571	-45 - 19i
3124	-49 - 55i	3188	-49 - 41i	3252	-47 - 55i	3316	-47 - 41i	3380	-49 - 9i	3444	-49 - 23i	3508	-47 - 9i	3572	-47 - 23i
3125	-49 - 53i	3189	-49 - 43i	3253	-47 - 53i	3317	-47 - 43i	3381	-49 - 11i	3445	-49 - 21i	3509	-47 - 11i	3573	-47 - 21i
3126	-13 - 73i	3190	-51 - 41i	3254	-45 - 55i	3318	-45 - 41i	3382	-51 - 9i	3446	-51 - 23i	3510	-45 - 9i	3574	-45 - 23i
3127	-51 - 53i	3191	-51 - 43i	3255	-45 - 53i	3319	-45 - 43i	3383	-51 - 11i	3447	-51 - 21i	3511	-45 - 11i	3575	-45 - 21i
3128	-55 - 49i	3192	-55 - 47i	3256	-41 - 49i	3320	-41 - 47i	3384	-55 - 15i	3448	-55 - 17i	3512	-41 - 15i	3576	-41 - 17i
3129	-73 - 13i	3193	-55 - 45i	3257	-41 - 51i	3321	-41 - 45i	3385	-55 - 13i	3449	-55 - 19i	3513	-41 - 13i	3577	-41 - 19i
3130	-53 - 49i	3194	-53 - 47i	3258	-43 - 49i	3322	-43 - 47i	3386	-53 - 15i	3450	-53 - 17i	3514	-43 - 15i	3578	-43 - 17i
3131	-53 - 51i	3195	-53 - 45i	3259	-43 - 51i	3323	-43 - 45i	3387	-53 - 13i	3451	-53 - 19i	3515	-43 - 13i	3579	-43 - 19i
3132	-73 - 9i	3196	-55 - 41i	3260	-41 - 55i	3324	-41 - 41i	3388	-55 - 9i	3452	-55 - 23i	3516	-41 - 9i	3580	-41 - 23i
3133	-73 - 11i	3197	-55 - 43i	3261	-41 - 53i	3325	-41 - 43i	3389	-55 - 11i	3453	-55 - 21i	3517	-41 - 11i	3581	-41 - 21i
3134	-11 - 73i	3198	-53 - 41i	3262	-43 - 55i	3326	-43 - 41i	3390	-53 - 9i	3454	-53 - 23i	3518	-43 - 9i	3582	-43 - 23i
3135	-53 - 53i	3199	-53 - 43i	3263	-43 - 53i	3327	-43 - 43i	3391	-53 - 11i	3455	-53 - 21i	3519	-43 - 11i	3583	-43 - 21i

FIG. 30

Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter	Value	Scatter
3584	-1 - 63i	3648	-1 - 33i	3712	-31 - 63i	3776	-31 - 33i	3840	-1 - 1i	3904	-1 - 31i	3968	-31 - 1i	4032	-31 - 31i
3585	-1 - 61i	3649	-1 - 35i	3713	-31 - 61i	3777	-31 - 35i	3841	-1 - 3i	3905	-1 - 29i	3969	-31 - 3i	4033	-31 - 29i
3586	-3 - 63i	3650	-3 - 33i	3714	-29 - 63i	3778	-29 - 33i	3842	-3 - 1i	3906	-3 - 31i	3970	-29 - 1i	4034	-29 - 31i
3587	-3 - 61i	3651	-3 - 35i	3715	-29 - 61i	3779	-29 - 35i	3843	-3 - 3i	3907	-3 - 29i	3971	-29 - 3i	4035	-29 - 29i
3588	-1 - 57i	3652	-1 - 39i	3716	-31 - 57i	3780	-31 - 39i	3844	-1 - 7i	3908	-1 - 25i	3972	-31 - 7i	4036	-31 - 25i
3589	-1 - 59i	3653	-1 - 37i	3717	-31 - 59i	3781	-31 - 37i	3845	-1 - 5i	3909	-1 - 27i	3973	-31 - 5i	4037	-31 - 27i
3590	-3 - 57i	3654	-3 - 39i	3718	-29 - 57i	3782	-29 - 39i	3846	-3 - 7i	3910	-3 - 25i	3974	-29 - 7i	4038	-29 - 25i
3591	-3 - 59i	3655	-3 - 37i	3719	-29 - 59i	3783	-29 - 37i	3847	-3 - 5i	3911	-3 - 27i	3975	-29 - 5i	4039	-29 - 27i
3592	-7 - 63i	3656	-7 - 33i	3720	-25 - 63i	3784	-25 - 33i	3848	-7 - 1i	3912	-7 - 31i	3976	-25 - 1i	4040	-25 - 31i
3593	-7 - 61i	3657	-7 - 35i	3721	-25 - 61i	3785	-25 - 35i	3849	-7 - 3i	3913	-7 - 29i	3977	-25 - 3i	4041	-25 - 29i
3594	-5 - 63i	3658	-5 - 33i	3722	-27 - 63i	3786	-27 - 33i	3850	-5 - 1i	3914	-5 - 31i	3978	-27 - 1i	4042	-27 - 31i
3595	-5 - 61i	3659	-5 - 35i	3723	-27 - 61i	3787	-27 - 35i	3851	-5 - 3i	3915	-5 - 29i	3979	-27 - 3i	4043	-27 - 29i
3596	-7 - 57i	3660	-7 - 39i	3724	-25 - 57i	3788	-25 - 39i	3852	-7 - 7i	3916	-7 - 25i	3980	-25 - 7i	4044	-25 - 25i
3597	-7 - 59i	3661	-7 - 37i	3725	-25 - 59i	3789	-25 - 37i	3853	-7 - 5i	3917	-7 - 27i	3981	-25 - 5i	4045	-25 - 27i
3598	-5 - 57i	3662	-5 - 39i	3726	-27 - 57i	3790	-27 - 39i	3854	-5 - 7i	3918	-5 - 25i	3982	-27 - 7i	4046	-27 - 25i
3599	-5 - 59i	3663	-5 - 37i	3727	-27 - 59i	3791	-27 - 37i	3855	-5 - 5i	3919	-5 - 27i	3983	-27 - 5i	4047	-27 - 27i
3600	-1 - 49i	3664	-1 - 47i	3728	-31 - 49i	3792	-31 - 47i	3856	-1 - 15i	3920	-1 - 17i	3984	-31 - 15i	4048	-31 - 17i
3601	-1 - 51i	3665	-1 - 45i	3729	-31 - 51i	3793	-31 - 45i	3857	-1 - 13i	3921	-1 - 19i	3985	-31 - 13i	4049	-31 - 19i
3602	-3 - 49i	3666	-3 - 47i	3730	-29 - 49i	3794	-29 - 47i	3858	-3 - 15i	3922	-3 - 17i	3986	-29 - 15i	4050	-29 - 17i
3603	-3 - 51i	3667	-3 - 45i	3731	-29 - 51i	3795	-29 - 45i	3859	-3 - 13i	3923	-3 - 19i	3987	-29 - 13i	4051	-29 - 19i
3604	-1 - 55i	3668	-1 - 41i	3732	-31 - 55i	3796	-31 - 41i	3860	-1 - 9i	3924	-1 - 23i	3988	-31 - 9i	4052	-31 - 23i
3605	-1 - 53i	3669	-1 - 43i	3733	-31 - 53i	3797	-31 - 43i	3861	-1 - 11i	3925	-1 - 21i	3989	-31 - 11i	4053	-31 - 21i
3606	-3 - 55i	3670	-3 - 41i	3734	-29 - 55i	3798	-29 - 41i	3862	-3 - 9i	3926	-3 - 23i	3990	-29 - 9i	4054	-29 - 23i
3607	-3 - 53i	3671	-3 - 43i	3735	-29 - 53i	3799	-29 - 43i	3863	-3 - 11i	3927	-3 - 21i	3991	-29 - 11i	4055	-29 - 21i
3608	-7 - 49i	3672	-7 - 47i	3736	-25 - 49i	3800	-25 - 47i	3864	-7 - 15i	3928	-7 - 17i	3992	-25 - 15i	4056	-25 - 17i
3609	-7 - 51i	3673	-7 - 45i	3737	-25 - 51i	3801	-25 - 45i	3865	-7 - 13i	3929	-7 - 19i	3993	-25 - 13i	4057	-25 - 19i
3610	-5 - 49i	3674	-5 - 47i	3738	-27 - 49i	3802	-27 - 47i	3866	-5 - 15i	3930	-5 - 17i	3994	-27 - 15i	4058	-27 - 17i
3611	-5 - 51i	3675	-5 - 45i	3739	-27 - 51i	3803	-27 - 45i	3867	-5 - 13i	3931	-5 - 19i	3995	-27 - 13i	4059	-27 - 19i
3612	-7 - 55i	3676	-7 - 41i	3740	-25 - 55i	3804	-25 - 41i	3868	-7 - 9i	3932	-7 - 23i	3996	-25 - 9i	4060	-25 - 23i
3613	-7 - 53i	3677	-7 - 43i	3741	-25 - 53i	3805	-25 - 43i	3869	-7 - 11i	3933	-7 - 21i	3997	-25 - 11i	4061	-25 - 21i
3614	-5 - 55i	3678	-5 - 41i	3742	-27 - 55i	3806	-27 - 41i	3870	-5 - 9i	3934	-5 - 23i	3998	-27 - 9i	4062	-27 - 23i
3615	-5 - 53i	3679	-5 - 43i	3743	-27 - 53i	3807	-27 - 43i	3871	-5 - 11i	3935	-5 - 21i	3999	-27 - 11i	4063	-27 - 21i

FIG. 31

3616	-15 - 63i	3680	-15 - 33i	3744	-17 - 63i	3808	-17 - 33i	3872	-15 - 1i	3936	-15 - 31i	4000	-17 - 1i	4064	-17 - 31i
3617	-15 - 61i	3681	-15 - 35i	3745	-17 - 61i	3809	-17 - 35i	3873	-15 - 3i	3937	-15 - 29i	4001	-17 - 3i	4065	-17 - 29i
3618	-13 - 63i	3682	-13 - 33i	3746	-19 - 63i	3810	-19 - 33i	3874	-13 - 1i	3938	-13 - 31i	4002	-19 - 1i	4066	-19 - 31i
3619	-13 - 61i	3683	-13 - 35i	3747	-19 - 61i	3811	-19 - 35i	3875	-13 - 3i	3939	-13 - 29i	4003	-19 - 3i	4067	-19 - 29i
3620	-15 - 57i	3684	-15 - 39i	3748	-17 - 57i	3812	-17 - 39i	3876	-15 - 7i	3940	-15 - 25i	4004	-17 - 7i	4068	-17 - 25i
3621	-15 - 59i	3685	-15 - 37i	3749	-17 - 59i	3813	-17 - 37i	3877	-15 - 5i	3941	-15 - 27i	4005	-17 - 5i	4069	-17 - 27i
3622	-13 - 57i	3686	-13 - 39i	3750	-19 - 57i	3814	-19 - 39i	3878	-13 - 7i	3942	-13 - 25i	4006	-19 - 7i	4070	-19 - 25i
3623	-13 - 59i	3687	-13 - 37i	3751	-19 - 59i	3815	-19 - 37i	3879	-13 - 5i	3943	-13 - 27i	4007	-19 - 5i	4071	-19 - 27i
3624	-9 - 63i	3688	-9 - 33i	3752	-23 - 63i	3816	-23 - 33i	3880	-9 - 1i	3944	-9 - 31i	4008	-23 - 1i	4072	-23 - 31i
3625	-9 - 61i	3689	-9 - 35i	3753	-23 - 61i	3817	-23 - 35i	3881	-9 - 3i	3945	-9 - 29i	4009	-23 - 3i	4073	-23 - 29i
3626	-11 - 63i	3690	-11 - 33i	3754	-21 - 63i	3818	-21 - 33i	3882	-11 - 1i	3946	-11 - 31i	4010	-21 - 1i	4074	-21 - 31i
3627	-11 - 61i	3691	-11 - 35i	3755	-21 - 61i	3819	-21 - 35i	3883	-11 - 3i	3947	-11 - 29i	4011	-21 - 3i	4075	-21 - 29i
3628	-9 - 57i	3692	-9 - 39i	3756	-23 - 57i	3820	-23 - 39i	3884	-9 - 7i	3948	-9 - 25i	4012	-23 - 7i	4076	-23 - 25i
3629	-9 - 59i	3693	-9 - 37i	3757	-23 - 59i	3821	-23 - 37i	3885	-9 - 5i	3949	-9 - 27i	4013	-23 - 5i	4077	-23 - 27i
3630	-11 - 57i	3694	-11 - 39i	3758	-21 - 57i	3822	-21 - 39i	3886	-11 - 7i	3950	-11 - 25i	4014	-21 - 7i	4078	-21 - 25i
3631	-11 - 59i	3695	-11 - 37i	3759	-21 - 59i	3823	-21 - 37i	3887	-11 - 5i	3951	-11 - 27i	4015	-21 - 5i	4079	-21 - 27i
3632	-15 - 49i	3696	-15 - 47i	3760	-17 - 49i	3824	-17 - 47i	3888	-15 - 15i	3952	-15 - 17i	4016	-17 - 15i	4080	-17 - 17i
3633	-15 - 51i	3697	-15 - 45i	3761	-17 - 51i	3825	-17 - 45i	3889	-15 - 13i	3953	-15 - 19i	4017	-17 - 13i	4081	-17 - 19i
3634	-13 - 49i	3698	-13 - 47i	3762	-19 - 49i	3826	-19 - 47i	3890	-13 - 15i	3954	-13 - 17i	4018	-19 - 15i	4082	-19 - 17i
3635	-13 - 51i	3699	-13 - 45i	3763	-19 - 51i	3827	-19 - 45i	3891	-13 - 13i	3955	-13 - 19i	4019	-19 - 13i	4083	-19 - 19i
3636	-15 - 55i	3700	-15 - 41i	3764	-17 - 55i	3828	-17 - 41i	3892	-15 - 9i	3956	-15 - 23i	4020	-17 - 9i	4084	-17 - 23i
3637	-15 - 53i	3701	-15 - 43i	3765	-17 - 53i	3829	-17 - 43i	3893	-15 - 11i	3957	-15 - 21i	4021	-17 - 11i	4085	-17 - 21i
3638	-13 - 55i	3702	-13 - 41i	3766	-19 - 55i	3830	-19 - 41i	3894	-13 - 9i	3958	-13 - 23i	4022	-19 - 9i	4086	-19 - 23i
3639	-13 - 53i	3703	-13 - 43i	3767	-19 - 53i	3831	-19 - 43i	3895	-13 - 11i	3959	-13 - 21i	4023	-19 - 11i	4087	-19 - 21i
3640	-9 - 49i	3704	-9 - 47i	3768	-23 - 49i	3832	-23 - 47i	3896	-9 - 15i	3960	-9 - 17i	4024	-23 - 15i	4088	-23 - 17i
3641	-9 - 51i	3705	-9 - 45i	3769	-23 - 51i	3833	-23 - 45i	3897	-9 - 13i	3961	-9 - 19i	4025	-23 - 13i	4089	-23 - 19i
3642	-11 - 49i	3706	-11 - 47i	3770	-21 - 49i	3834	-21 - 47i	3898	-11 - 15i	3962	-11 - 17i	4026	-21 - 15i	4090	-21 - 17i
3643	-11 - 51i	3707	-11 - 45i	3771	-21 - 51i	3835	-21 - 45i	3899	-11 - 13i	3963	-11 - 19i	4027	-21 - 13i	4091	-21 - 19i
3644	-9 - 55i	3708	-9 - 41i	3772	-23 - 55i	3836	-23 - 41i	3900	-9 - 9i	3964	-9 - 23i	4028	-23 - 9i	4092	-23 - 23i
3645	-9 - 53i	3709	-9 - 43i	3773	-23 - 53i	3837	-23 - 43i	3901	-9 - 11i	3965	-9 - 21i	4029	-23 - 11i	4093	-23 - 21i
3646	-11 - 55i	3710	-11 - 41i	3774	-21 - 55i	3838	-21 - 41i	3902	-11 - 9i	3966	-11 - 23i	4030	-21 - 9i	4094	-21 - 23i
3647	-11 - 53i	3711	-11 - 43i	3775	-21 - 53i	3839	-21 - 43i	3903	-11 - 11i	3967	-11 - 21i	4031	-21 - 11i	4095	-21 - 21i

Fig. 32

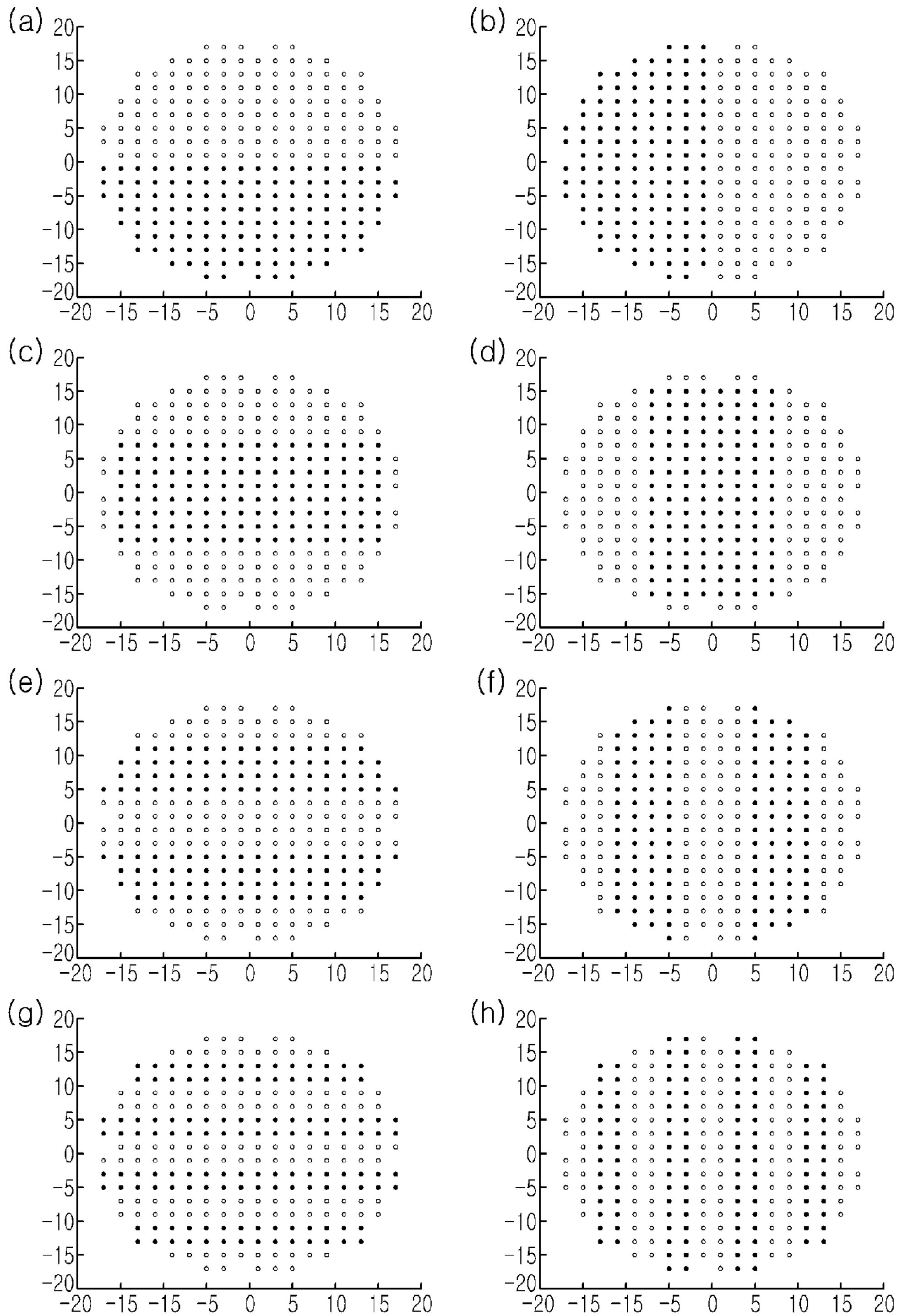


Fig. 33

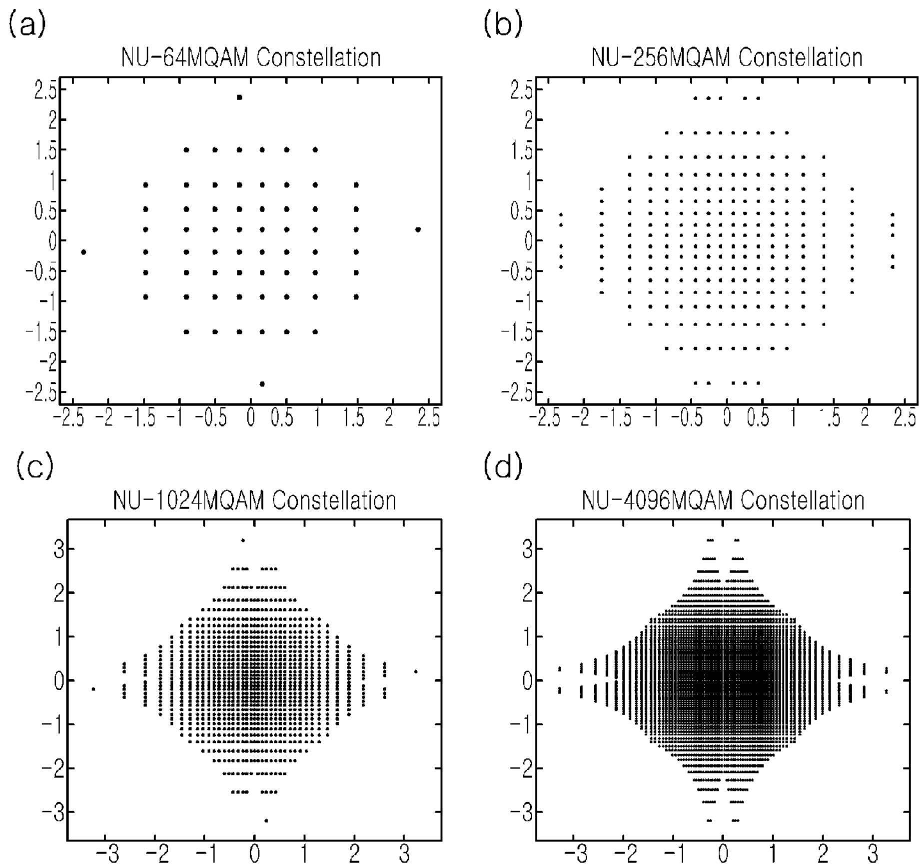

(a)
NU-64MQAM Constellation
(b)
NU-256MQAM Constellation
(c)
NU-1024MQAM Constellation
(d)
NU-4096MQAM Constellation

Fig. 34

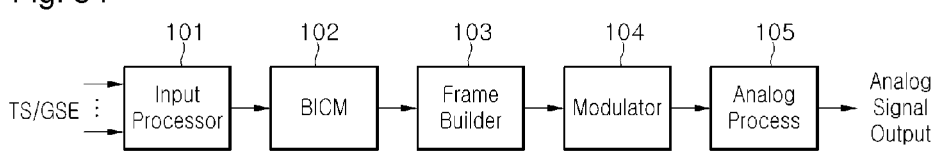

101
102
103
104
105
TS/GSE
Input Processor
BICM
Frame Builder
Modulator
Analog Process
Analog Signal Output

FIG. 35

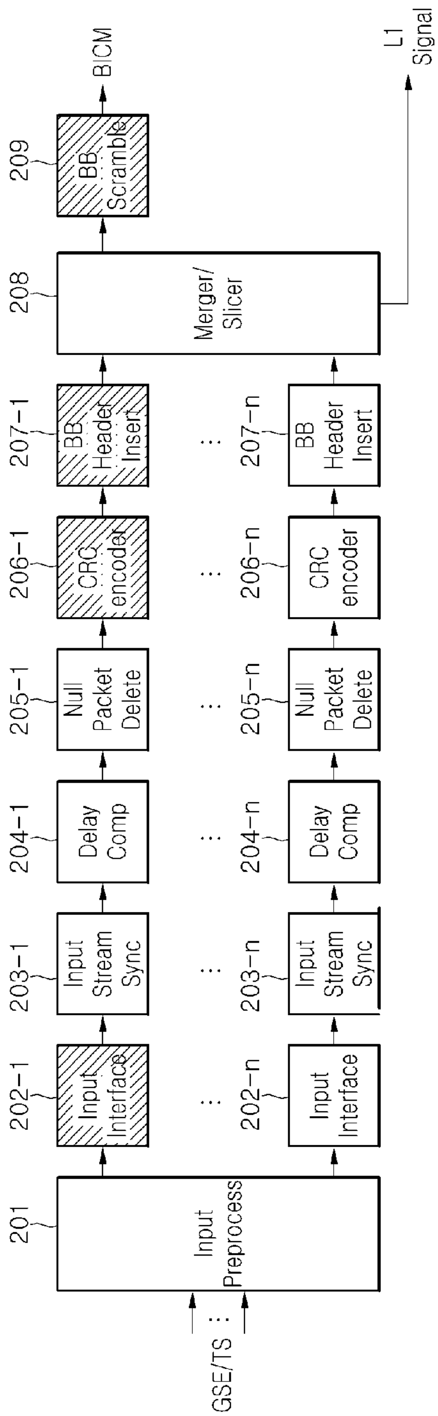

GSE/TS
201
Input Preprocess
202-1
Input Interface
202-n
Input Interface
203-1
Input Stream Sync
203-n
Input Stream Sync
204-1
Delay Comp
204-n
Delay Comp
205-1
Null Packet Delete
205-n
Null Packet Delete
206-1
CRC encoder
206-n
CRC encoder
207-1
BB Header Insert
207-n
BB Header Insert
208
Merger/ Slicer
209
BB Scramble
BICM
L1 Signal

Fig. 36

TS/GS (2 bits)	SIS/MIS (1 bit)	CCM/ACM (1 bit)	ISSYI (1 bit)	NPD (1bit)	EXT (2bits)
00 = GFPS 11 = TS 01 = GCS 10 = GSE	1 = single 0 = multiple	1 = CCM 0 = ACM	1 = active 0 = not-active	1= active 0 = not-active	Reserved for future use

Field	Size (Bytes)	Description
MATYPE	2	As described above
UPL	2	User Packet Length in bits, in the range [0,65535]
DFL	2	Data Field Length in bits, in the renge [0,53760]
SYNC	1	A copy of the User Packet Sync-byte
SYNCD	2	The distance in bits from the beginning of the DATA FIELD to the first complete UP of the data field. SYNCD=0_D means that the first UP is aligned to the beginning of the Data Field. SYNCD = 65535_D means that no UP starts in the DATA FIELD.
CRC-8 MODE	1	The XOR of the CRC-8 (1-byte) field with the MODE field (1-byte). CRC-8 is the error detection code applied to the first 9 bytes of the BBHEADER. MODE (8 bits) shall be: • 0_D Normal Mode • 1_D High Efficiency Mode • Other values : reserved for future use.

FIG. 37

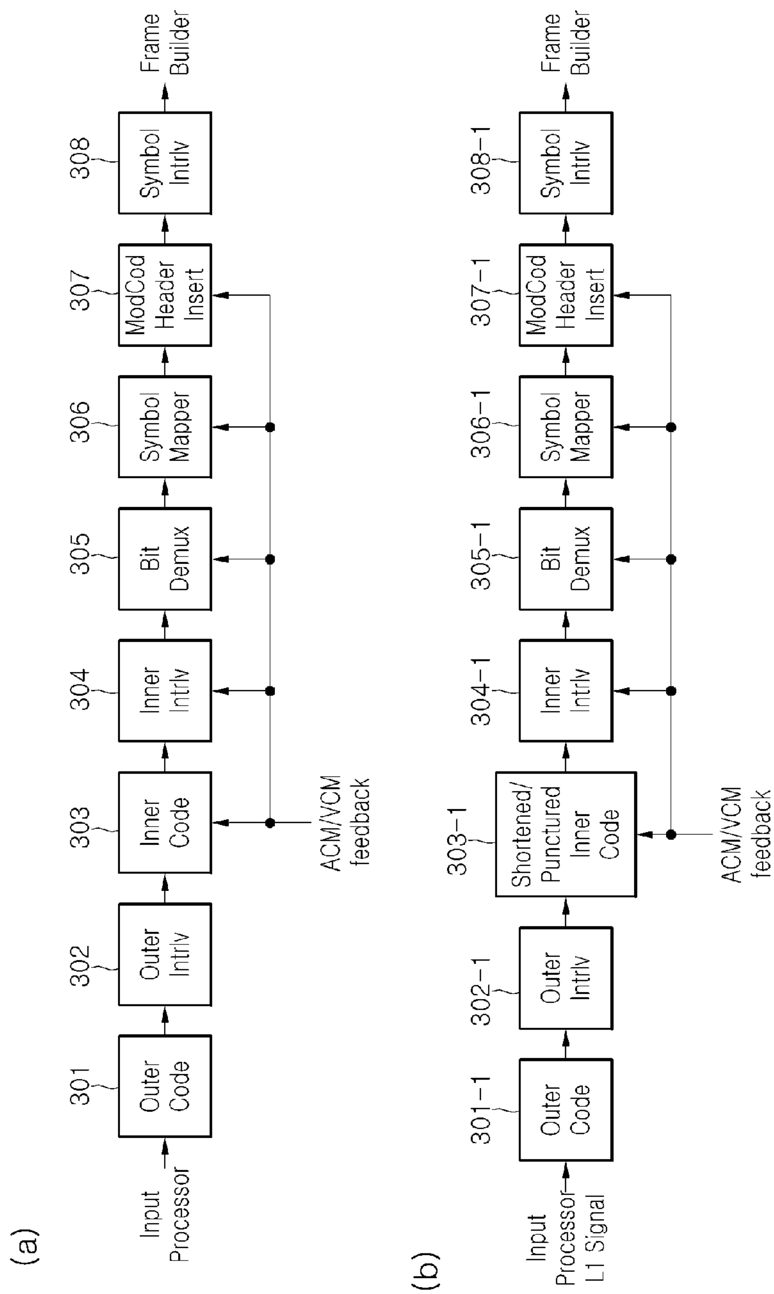

(a)
Input Processor
301
Outer Code
302
Outer Intrlv
303
Inner Code
304
Inner Intrlv
305
Bit Demux
306
Symbol Mapper
307
ModCod Header Insert
308
Symbol Intrlv
Frame Builder
ACM/VCM feedback
(b)
Input Processor L1 Signal
301-1
Outer Code
302-1
Outer Intrlv
303-1
Shortened/ Punctured Inner Code
304-1
Inner Intrlv
305-1
Bit Demux
306-1
Symbol Mapper
307-1
ModCod Header Insert
308-1
Symbol Intrlv
Frame Builder
ACM/VCM feedback

Fig. 38

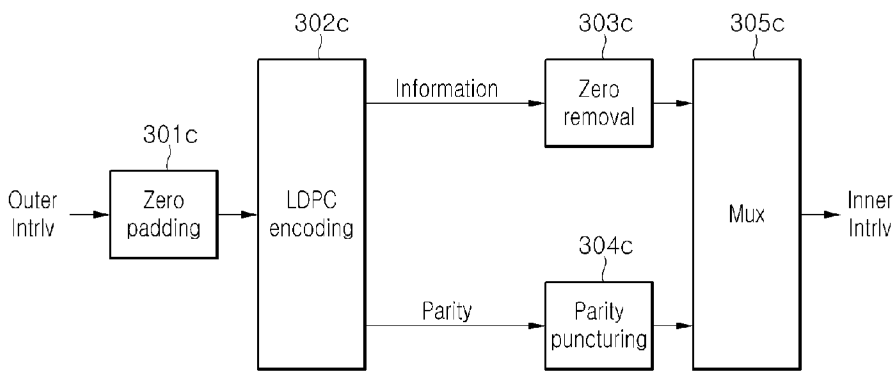

302c
303c
305c
Information
Zero
removal
301c
Outer
Intrlv
Zero
padding
LDPC
encoding
Mux
Inner
Intrlv
304c
Parity
Parity
puncturing

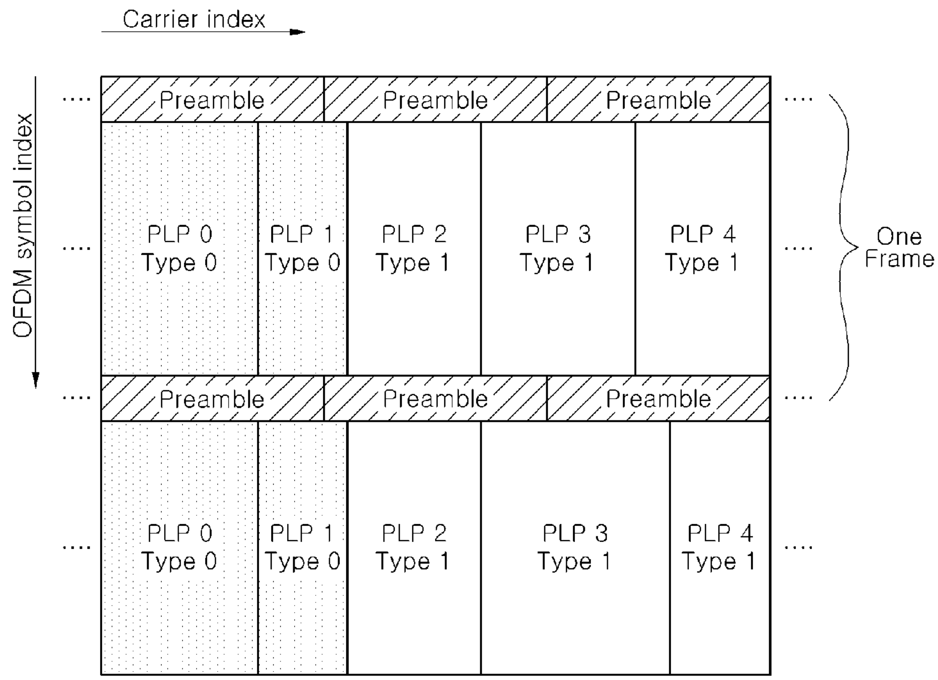
Fig. 39

Capacity (bit/s/Hz)			Case 1 Modulation	Case 2 Modulation
6	1/2	3.0	NU-MQAM	NU-QAM
	2/3	4.0	NU-MQAM	NU-QAM
	3/4	4.5	NU-MQAM	NU-MQAM
	4/5	4.8	MQAM	MQAM
	5/6	5.0	MQAM	MQAM
	8/9	5.3	MQAM	MQAM
	9/10	5.4	MQAM	MQAM
8	1/2	4.0	NU-MQAM	NU-QAM
	2/3	5.3	NU-MQAM	NU-QAM
	3/4	6.0	NU-MQAM	NU-MQAM
	4/5	6.4	NU-MQAM	NU-MQAM
	5/6	6.7	MQAM	MQAM
	8/9	7.1	MQAM	MQAM
	9/10	7.2	MQAM	MQAM
10	1/2	5.0	NU-MQAM	NU-QAM
	2/3	6.7	NU-MQAM	NU-QAM
	3/4	7.5	NU-MQAM	NU-MQAM
	4/5	8.0	NU-MQAM	NU-MQAM
	5/6	8.3	NU-MQAM	NU-MQAM
	8/9	8.9	MQAM	MQAM
	9/10	9.0	MQAM	MQAM
12	1/2	6.0	NU-MQAM	NU-QAM
	2/3	8.0	NU-MQAM	NU-QAM
	3/4	9.0	NU-MQAM	NU-MQAM
	4/5	9.6	NU-MQAM	NU-MQAM
	5/6	10.0	NU-MQAM	NU-MQAM
	8/9	10.7	MQAM	MQAM
	9/10	10.8	MQAM	MQAM

Fig. 40

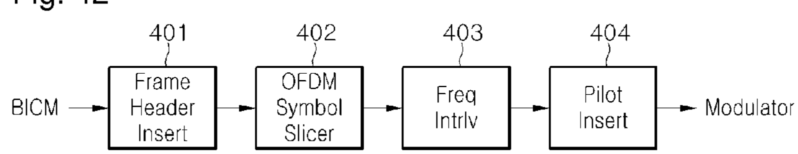
Capacity (bit/s/Hz)			Case 1 Modulation	Case 2 Modulation	Case 2 Modulation
2	1/2	3.0	QAM	QAM	QAM
	2/3	4.0	QAM	QAM	QAM
	3/4	4.5	QAM	QAM	QAM
	4/5	4.8	QAM	QAM	QAM
	5/6	5.0	QAM	QAM	QAM
	8/9	5.3	QAM	QAM	QAM
	9/10	5.4	QAM	QAM	QAM
4	1/2	3.0	QAM	QAM	QAM
	2/3	4.0	QAM	QAM	QAM
	3/4	4.5	QAM	QAM	QAM
	4/5	4.8	QAM	QAM	QAM
	5/6	5.0	QAM	QAM	QAM
	8/9	5.3	QAM	QAM	QAM
	9/10	5.4	QAM	QAM	QAM
6	1/2	3.0	QAM	QAM	QAM
	2/3	4.0	QAM	QAM	QAM
	3/4	4.5	QAM	QAM	QAM
	4/5	4.8	QAM	QAM	QAM
	5/6	5.0	QAM	QAM	QAM
	8/9	5.3	QAM	QAM	QAM
	9/10	5.4	QAM	QAM	QAM
8	1/2	4.0	QAM	QAM	QAM
	2/3	5.3	QAM	QAM	QAM
	3/4	6.0	QAM	QAM	QAM
	4/5	6.4	QAM	QAM	QAM
	5/6	6.7	QAM	QAM	QAM
	8/9	7.1	QAM	QAM	QAM
	9/10	7.2	QAM	QAM	QAM
10	1/2	5.0	NU-MQAM	NU-QAM	MQAM
	2/3	6.7	NU-MQAM	NU-QAM	MQAM
	3/4	7.5	NU-MQAM	NU-MQAM	MQAM
	4/5	8.0	NU-MQAM	NU-MQAM	MQAM
	5/6	8.3	NU-MQAM	NU-MQAM	MQAM
	8/9	8.9	MQAM	MQAM	MQAM
	9/10	9.0	MQAM	MQAM	MQAM
12	1/2	6.0	NU-MQAM	NU-QAM	MQAM
	2/3	8.0	NU-MQAM	NU-QAM	MQAM
	3/4	9.0	NU-MQAM	NU-MQAM	MQAM
	4/5	9.6	NU-MQAM	NU-MQAM	MQAM
	5/6	10.0	NU-MQAM	NU-MQAM	MQAM
	8/9	10.7	MQAM	MQAM	MQAM
	9/10	10.8	MQAM	MQAM	MQAM

Fig. 41



Carrier index
OFDM symbol index
Preamble
Preamble
Preamble
PLP 0
Type 0
PLP 1
Type 0
PLP 2
Type 1
PLP 3
Type 1
PLP 4
Type 1
One
Frame
Preamble
Preamble
Preamble
PLP 0
Type 0
PLP 1
Type 0
PLP 2
Type 1
PLP 3
Type 1
PLP 4
Type 1

Fig. 42



401
402
403
404
BICM
Frame Header Insert
OFDM Symbol Slicer
Freq Intrlv
Pilot Insert
Modulator

FIG. 43

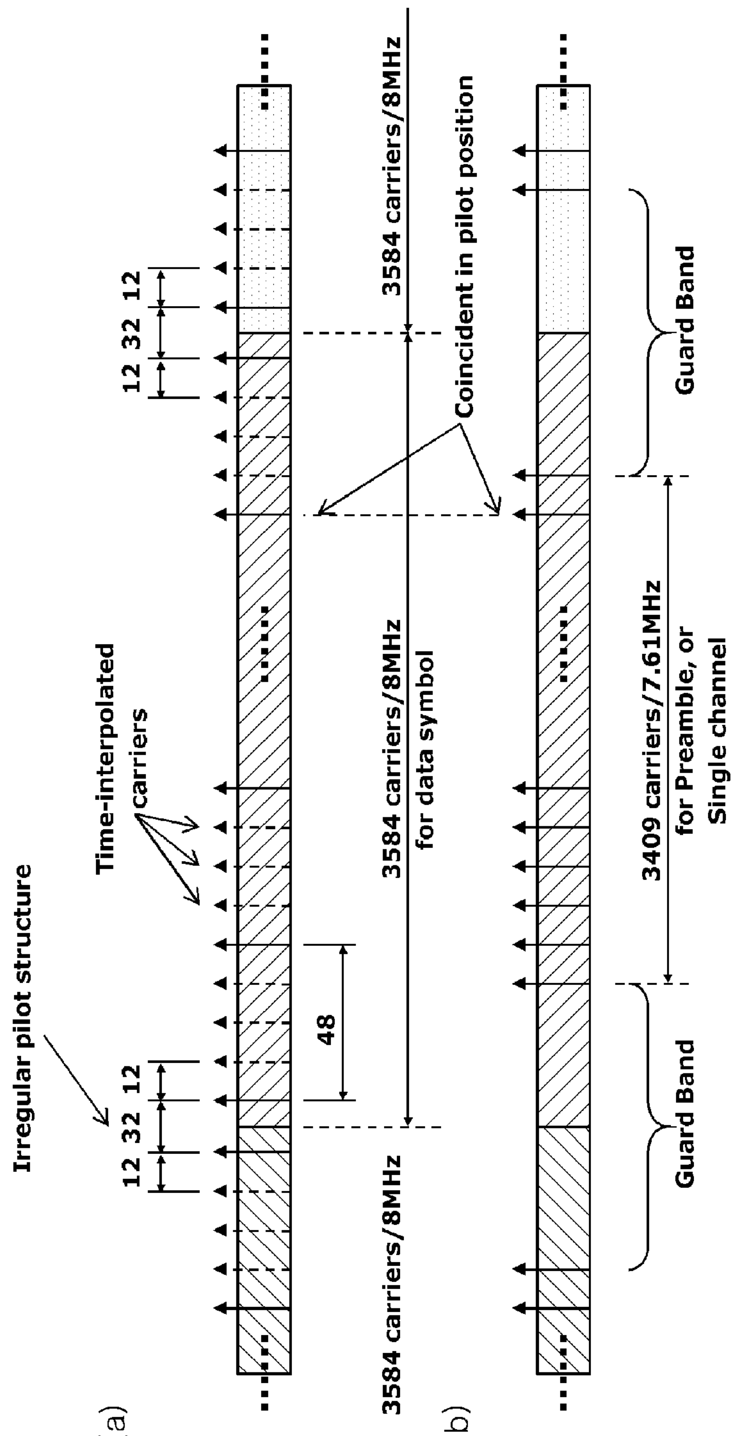

(a)
Irregular pilot structure
Time-interpolated carriers
12
32
12
48
3584 carriers/8MHz
3584 carriers/8MHz for data symbol
Coincident in pilot position
(b)
Guard Band
3409 carriers/7.61MHz for Preamble, or Single channel

FIG. 44

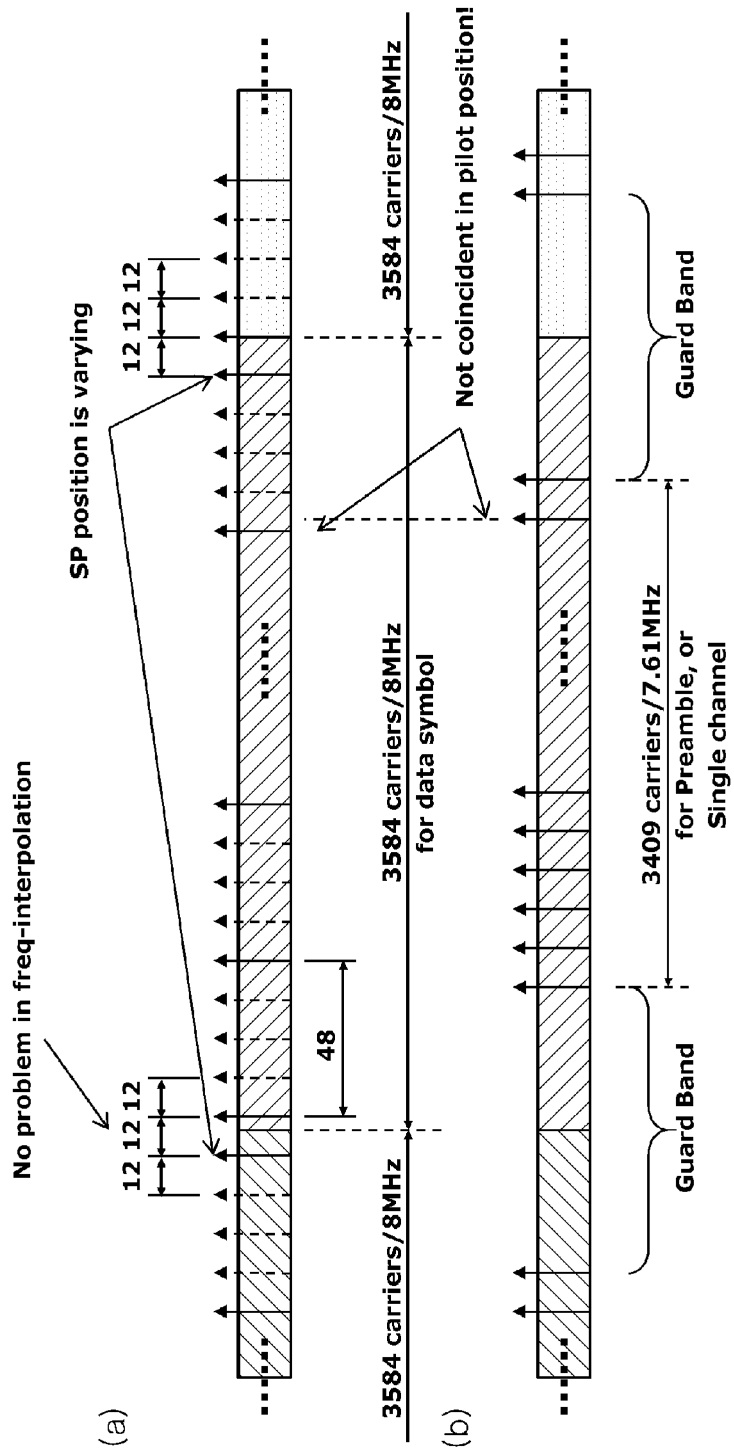
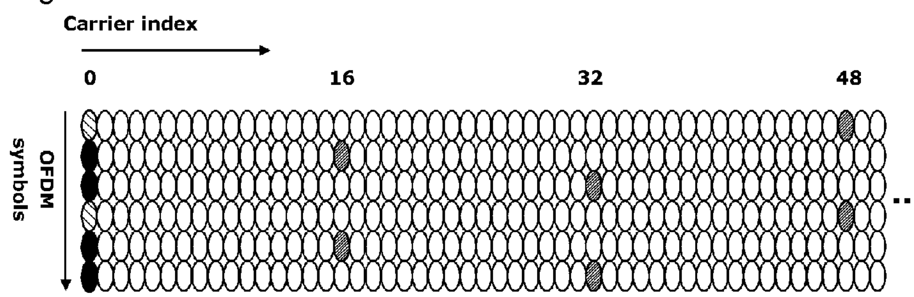
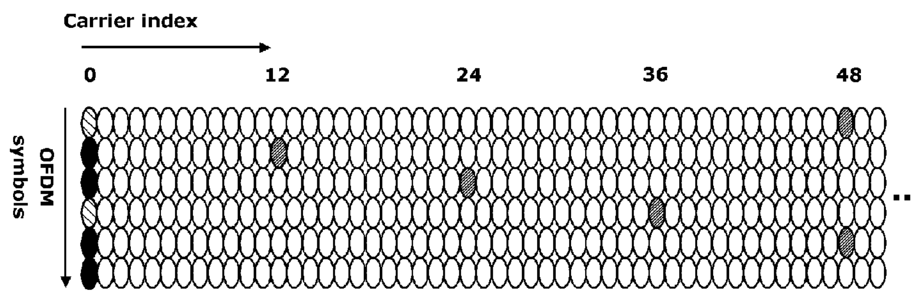

(a)
No problem in freq-interpolation
SP position is varying
12 12 12
12 12 12
48
3584 carriers/8MHz
3584 carriers/8MHz
for data symbol
3584 carriers/8MHz
(b)
Not coincident in pilot position!
Guard Band
3409 carriers/7.61MHz
for Preamble, or
Single channel
Guard Band

Fig. 45



PP5' (proposal)



PP5

FIG. 46

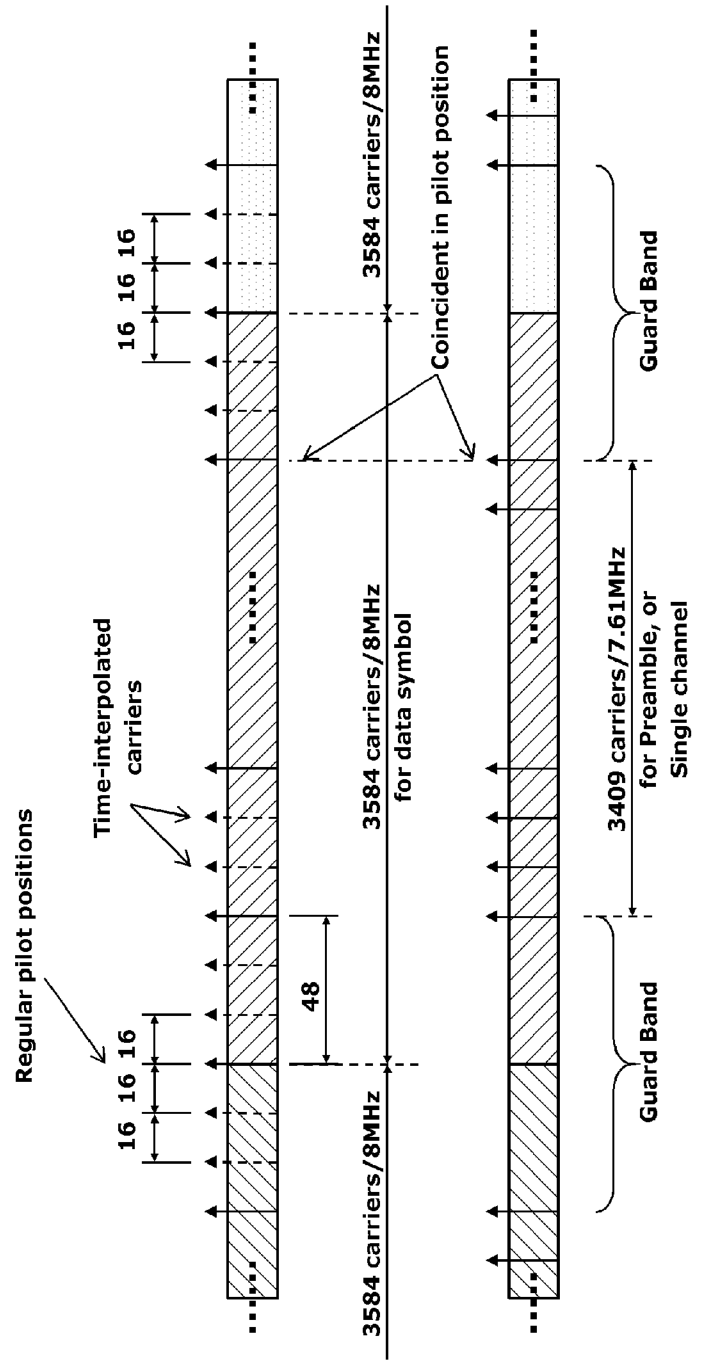
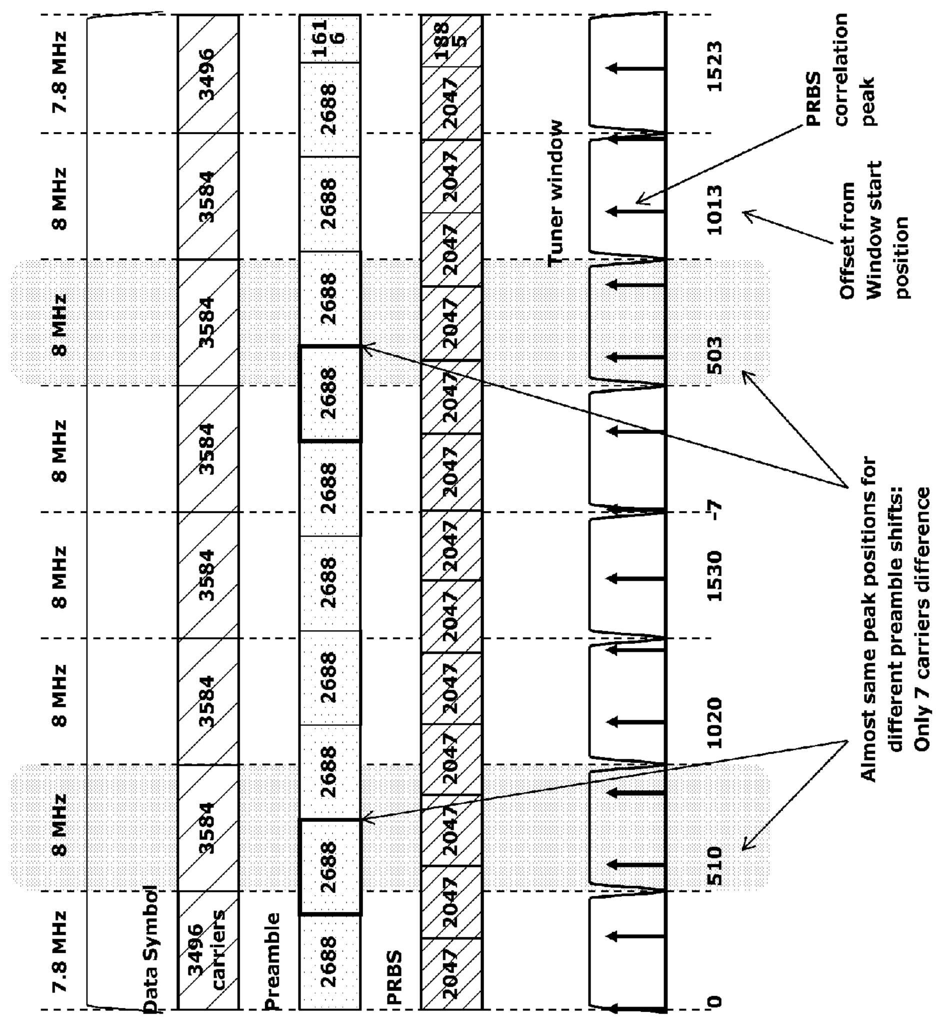

Regular pilot positions
Time-interpolated carriers
16 16 16
16 16 16
48
3584 carriers/8MHz
3584 carriers/8MHz for data symbol
3584 carriers/8MHz
Coincident in pilot position
Guard Band
3409 carriers/7.61MHz for Preamble, or Single channel
Guard Band

FIG. 47



7.8 MHz
8 MHz
8 MHz
8 MHz
8 MHz
8 MHz
8 MHz
7.8 MHz
Data Symbol
3496 carriers
3584
3584
3584
3584
3584
3584
3496
Preamble
2688
161 6
PRBS
2047
188 5
Tuner window
0
510
1020
1530
-7
503
1013
1523
PRBS correlation peak
Offset from Window start position
Almost same peak positions for different preamble shifts: Only 7 carriers difference

FIG. 48

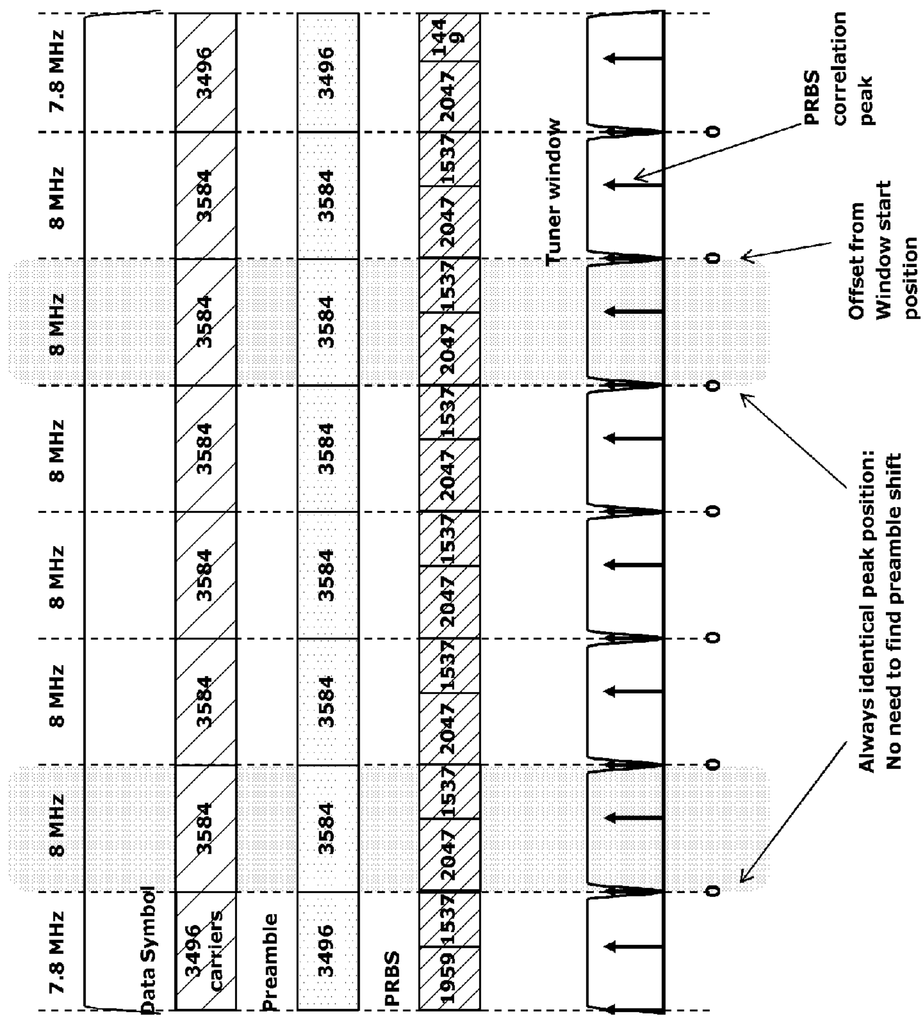

7.8 MHz
8 MHz
Data Symbol
3496 carriers
3584
3496
Preamble
PRBS
1959
1537
2047
1449
Tuner window
PRBS correlation peak
Offset from Window start position
Always identical peak position:
No need to find preamble shift
0

Fig. 49

Delay (μs)	0.2	0.4	0.8	1.2	2.5	15
Att. (dB)	−11	−14	−17	−23	−32	−40

Negligible Delay path

FIG. 50

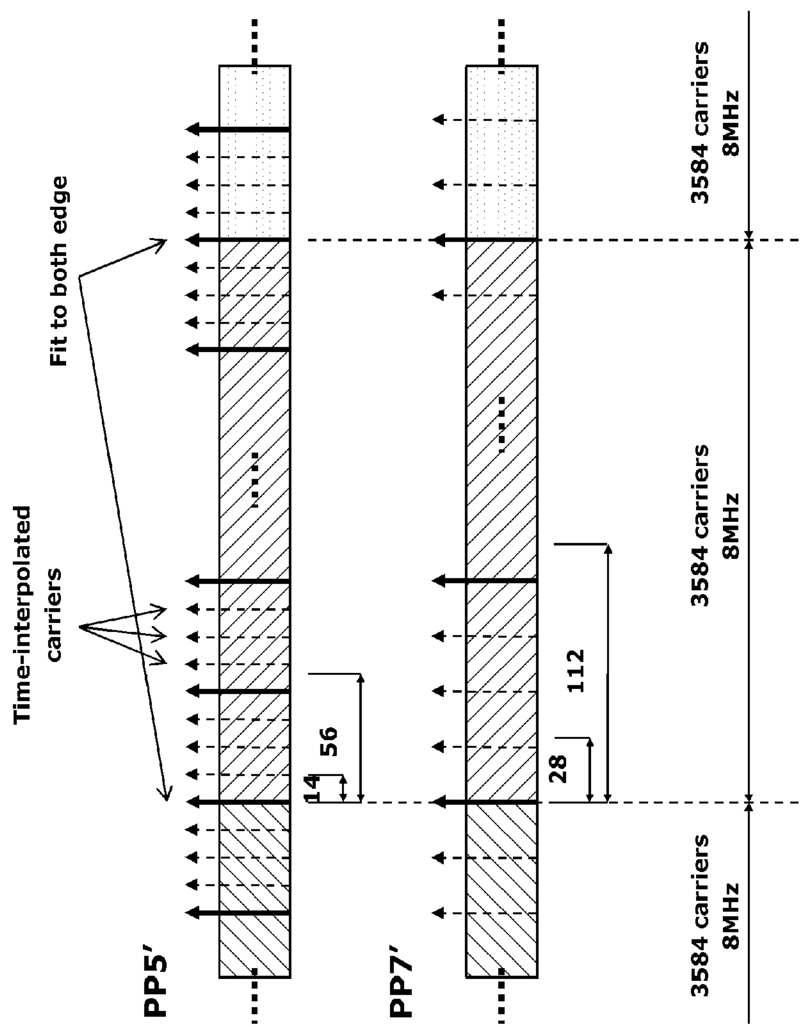

Time-interpolated carriers
Fit to both edge
PP5′
PP7′
56
14
112
28
3584 carriers 8MHz
3584 carriers 8MHz
3584 carriers 8MHz

Fig. 51

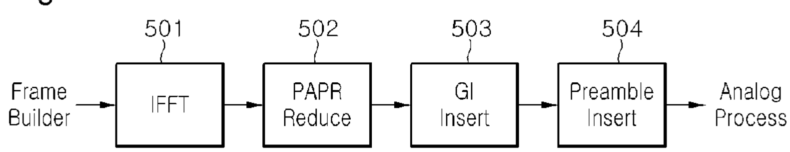

501
502
503
504
Frame Builder
IFFT
PAPR Reduce
GI Insert
Preamble Insert
Analog Process

Fig. 52

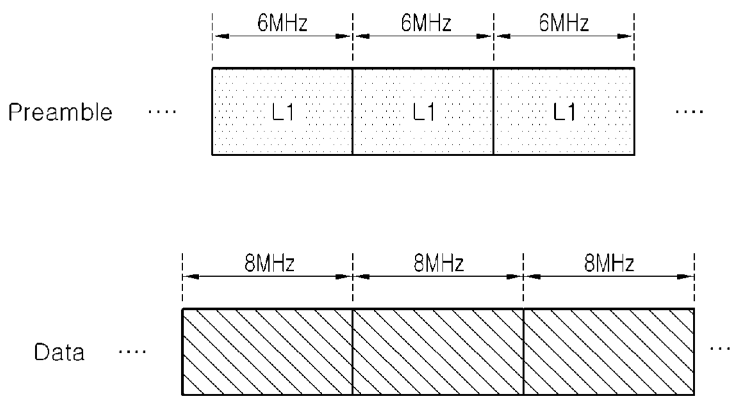


Fig. 53

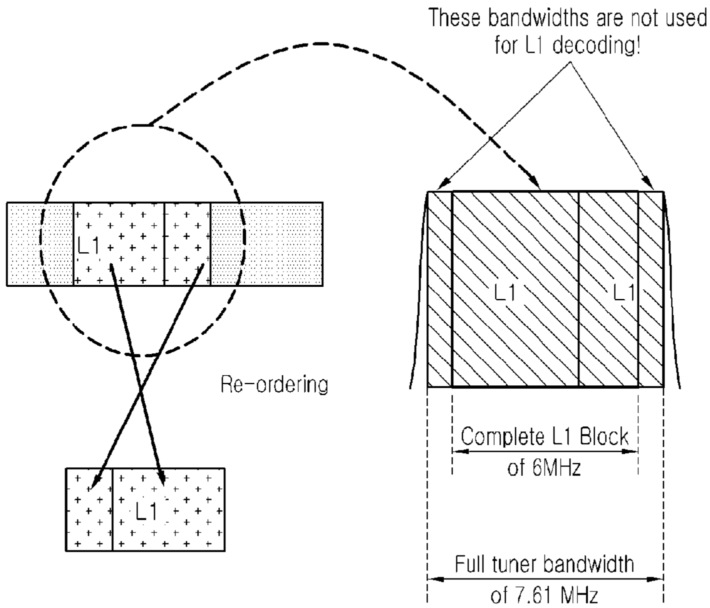


Fig. 54

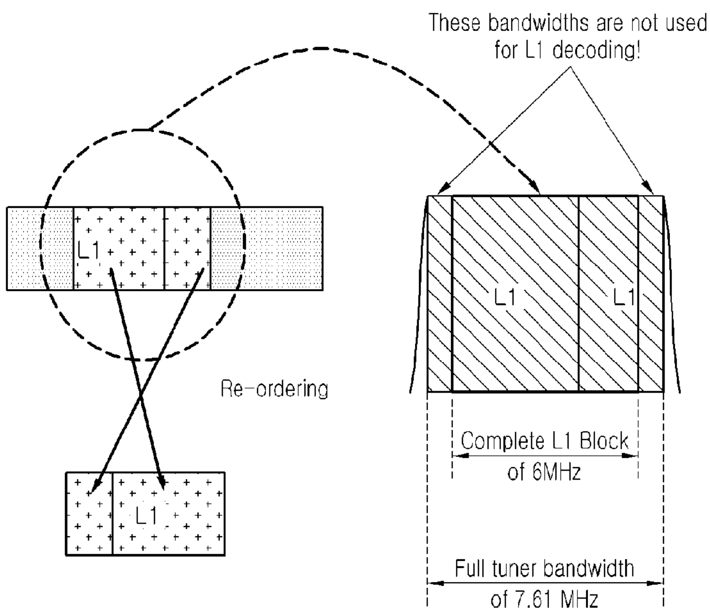


Fig. 55

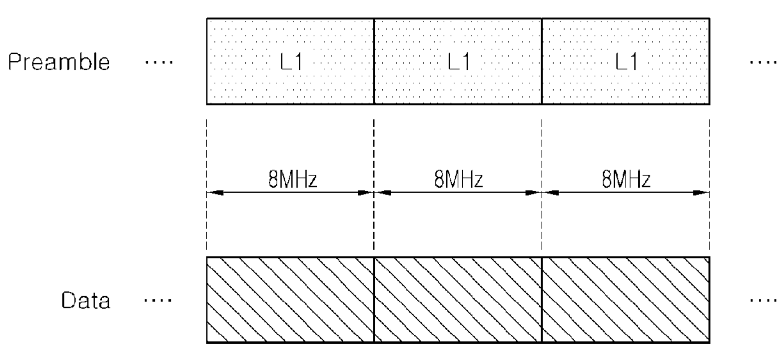


Fig. 56

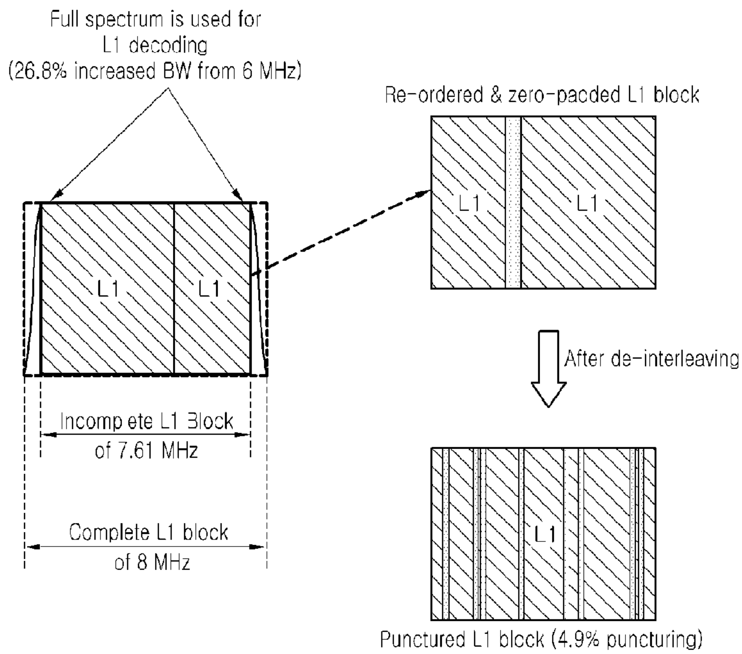


Fig. 57

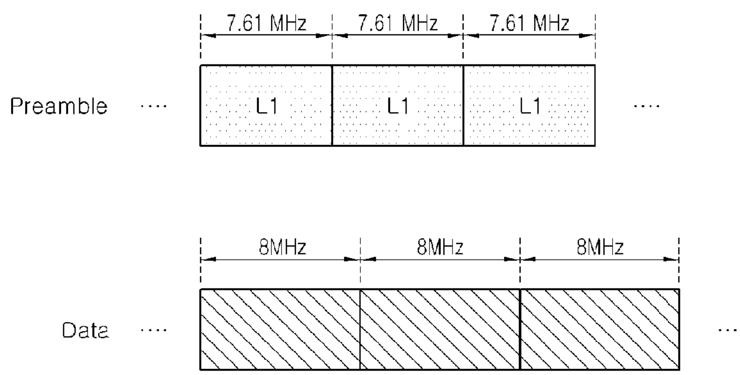


Fig. 58

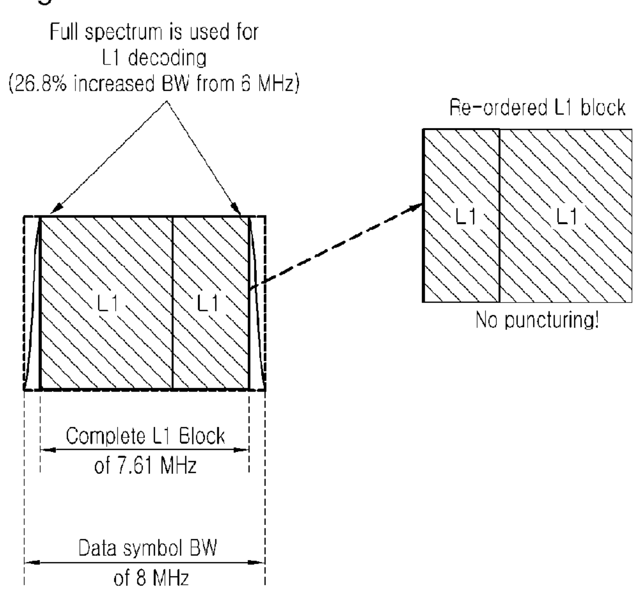


Fig. 59

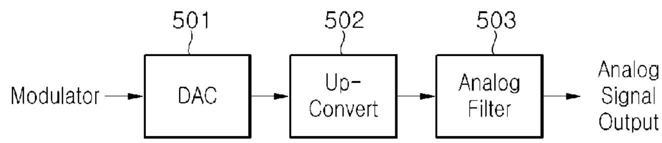


Fig. 60

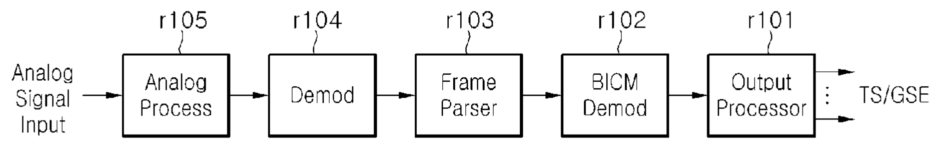


Fig. 61

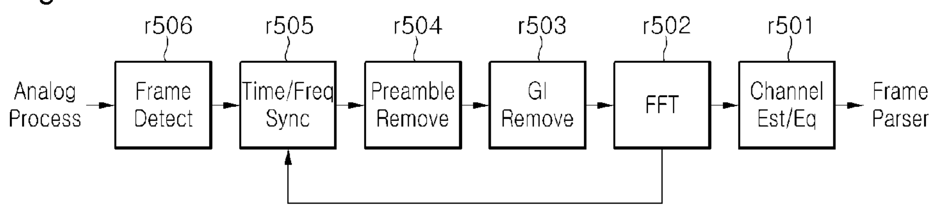


Fig. 62

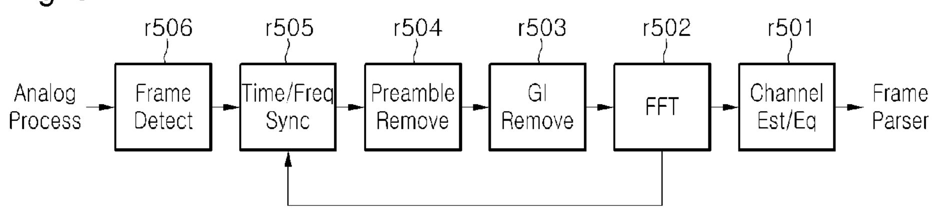


Fig. 63

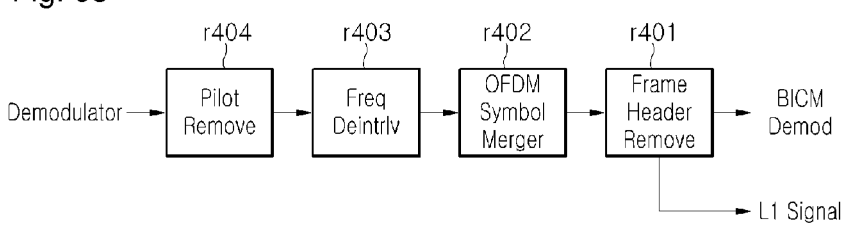


FIG. 64

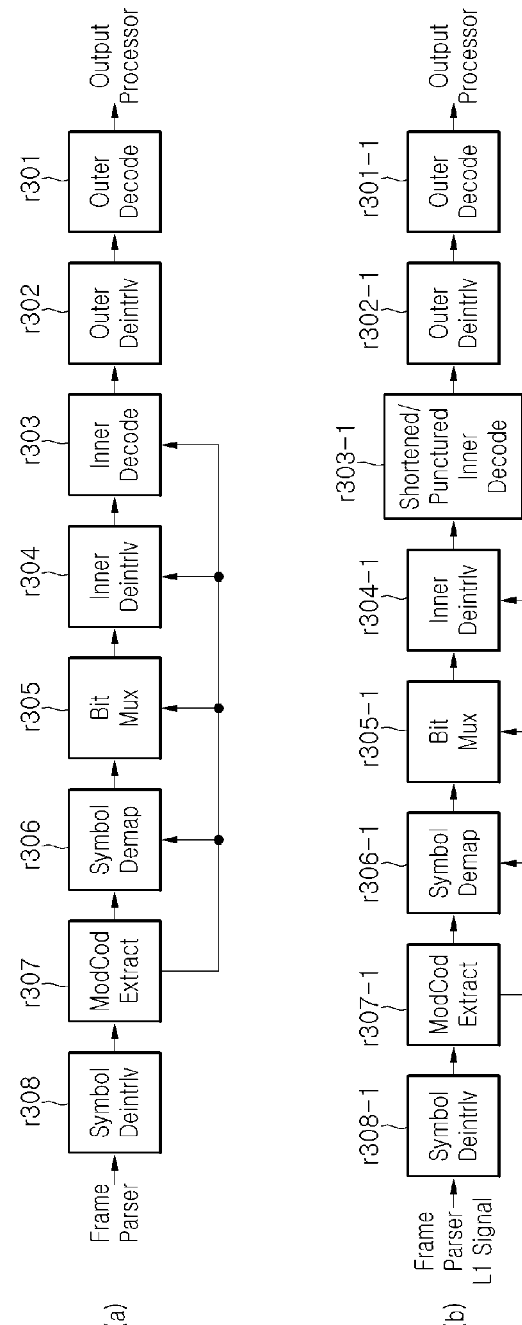

(a)
Frame Parser
r308
Symbol Deintrlv
r307
ModCod Extract
r306
Symbol Demap
r305
Bit Mux
r304
Inner Deintrlv
r303
Inner Decode
r302
Outer Deintrlv
r301
Outer Decode
Output Processor
(b)
Frame Parser
L1 Signal
r308-1
Symbol Deintrlv
r307-1
ModCod Extract
r306-1
Symbol Demap
r305-1
Bit Mux
r304-1
Inner Deintrlv
r303-1
Shortened/ Punctured Inner Decode
r302-1
Outer Deintrlv
r301-1
Outer Decode
Output Processor

Fig. 65

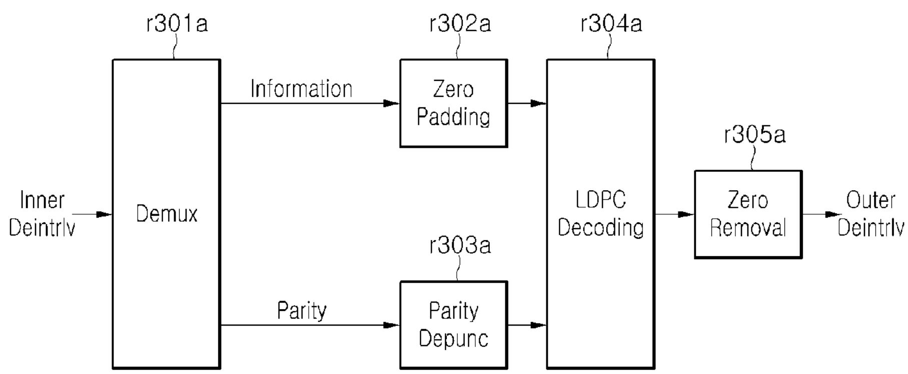
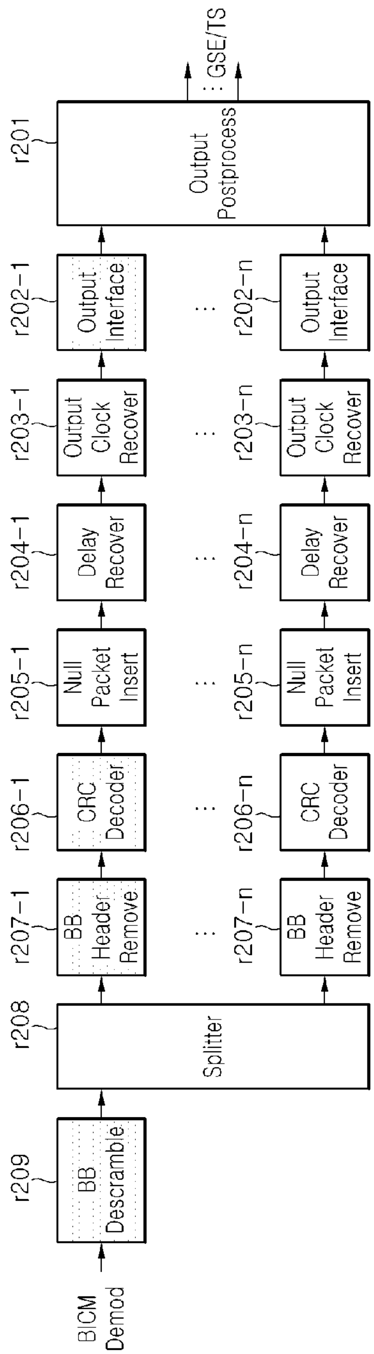

r301a
r302a
r304a
r305a
r303a
Information
Parity
Inner
Deintrlv
Demux
Zero
Padding
Parity
Depunc
LDPC
Decoding
Zero
Removal
Outer
Deintrlv

FIG. 66



BICM Demod
r209
BB Descramble
r208
Splitter
r207-1
BB Header Remove
r207-n
BB Header Remove
r206-1
CRC Decoder
r206-n
CRC Decoder
r205-1
Null Packet Insert
r205-n
Null Packet Insert
r204-1
Delay Recover
r204-n
Delay Recover
r203-1
Output Clock Recover
r203-n
Output Clock Recover
r202-1
Output Interface
r202-n
Output Interface
r201
Output Postprocess
GSE/TS

Fig. 67

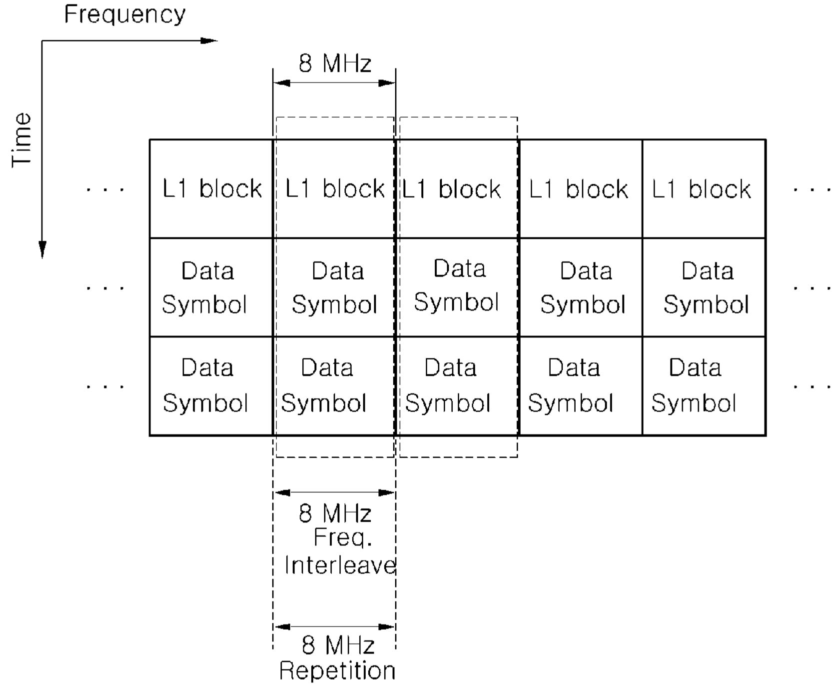

Frequency
Time
8 MHz
L1 block
L1 block
L1 block
L1 block
L1 block
Data Symbol
Data Symbol
Data Symbol
Data Symbol
Data Symbol
Data Symbol
Data Symbol
Data Symbol
Data Symbol
Data Symbol
8 MHz Freq. Interleave
8 MHz Repetition

Fig. 68

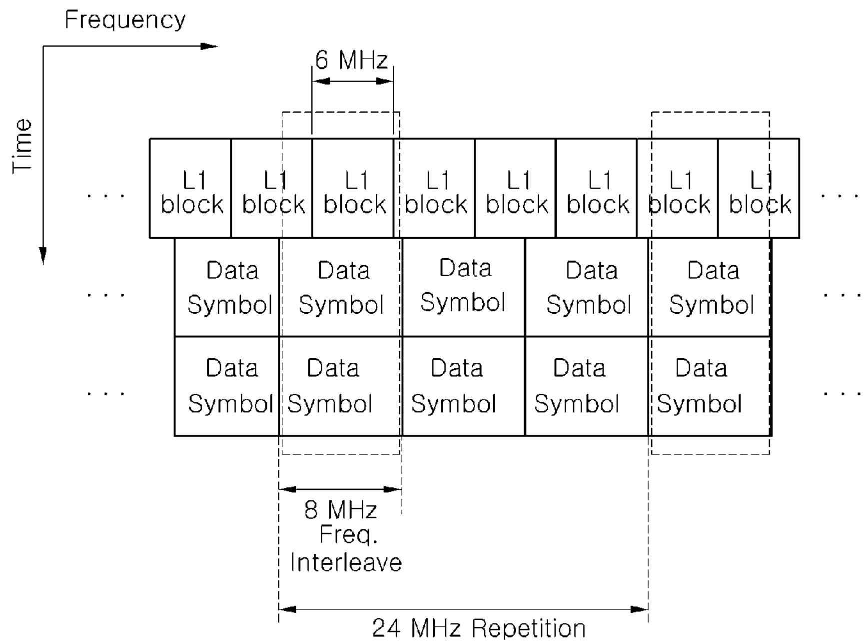

Frequency
Time
6 MHz
L1 block
L1 block
L1 block
L1 block
L1 block
L1 block
L1 block
L1 block
Data Symbol
Data Symbol
Data Symbol
Data Symbol
Data Symbol
Data Symbol
Data Symbol
Data Symbol
Data Symbol
Data Symbol
8 MHz Freq. Interleave
24 MHz Repetition

Fig. 69

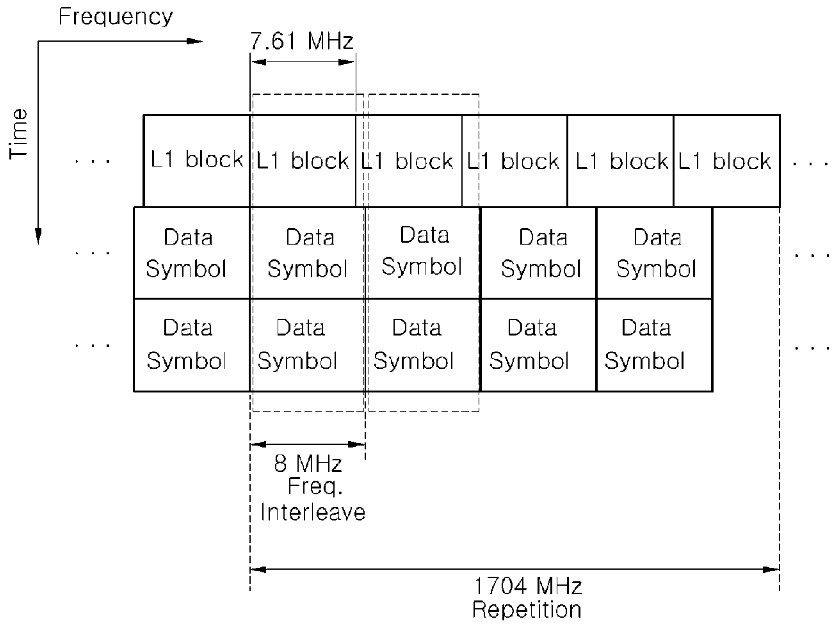


Fig. 70

Field	Bits	
L1_span	12	number of carriers spanned by L1 block within one OFDM symbol (Max=7.61 MHz)
num_chbon	3	number of bonded channels
num_dslice	8	number of data slices
num_plp	8	number of PLPs
num_notch	5	number of notch bands
for dslice {		
chbon_index	3	bonded channel index
dslice_start	9	start of data slice within one channel (8 MHz)
dslice_width	9	width of data slice
}		
for plp {		
dslice_id	8	data sliced ID
plp id	8	PLP ID
plp_type	1	PLP type (common/data)
plp_payload_type	5	PLP payload type (TS,GS,···)
}		
for notch {		
chbon_index	3	bonded channel index
notch_start	9	start of notch band within one channel (8 MHz)
notch_width	9	width of notch band
}		
gi	1	guard interval mode
sframe_id	16	superframe ID
frame_id	16	fraem ID
reserved	0	rfu
crc32	32	CRC32
Total	11760	

The number of L1 information bits varies according to various configurations/conditions

Fig. 71

L1 info (bits)	11760
L1 block (bits)	23520
16 - QAM symbols	5880
Total carriers	3408
Preamble SP distance	6
Data carriers	2840
Short LDPC	1.45
OFDM symbols	2.07

Maximum size

Fig. 72

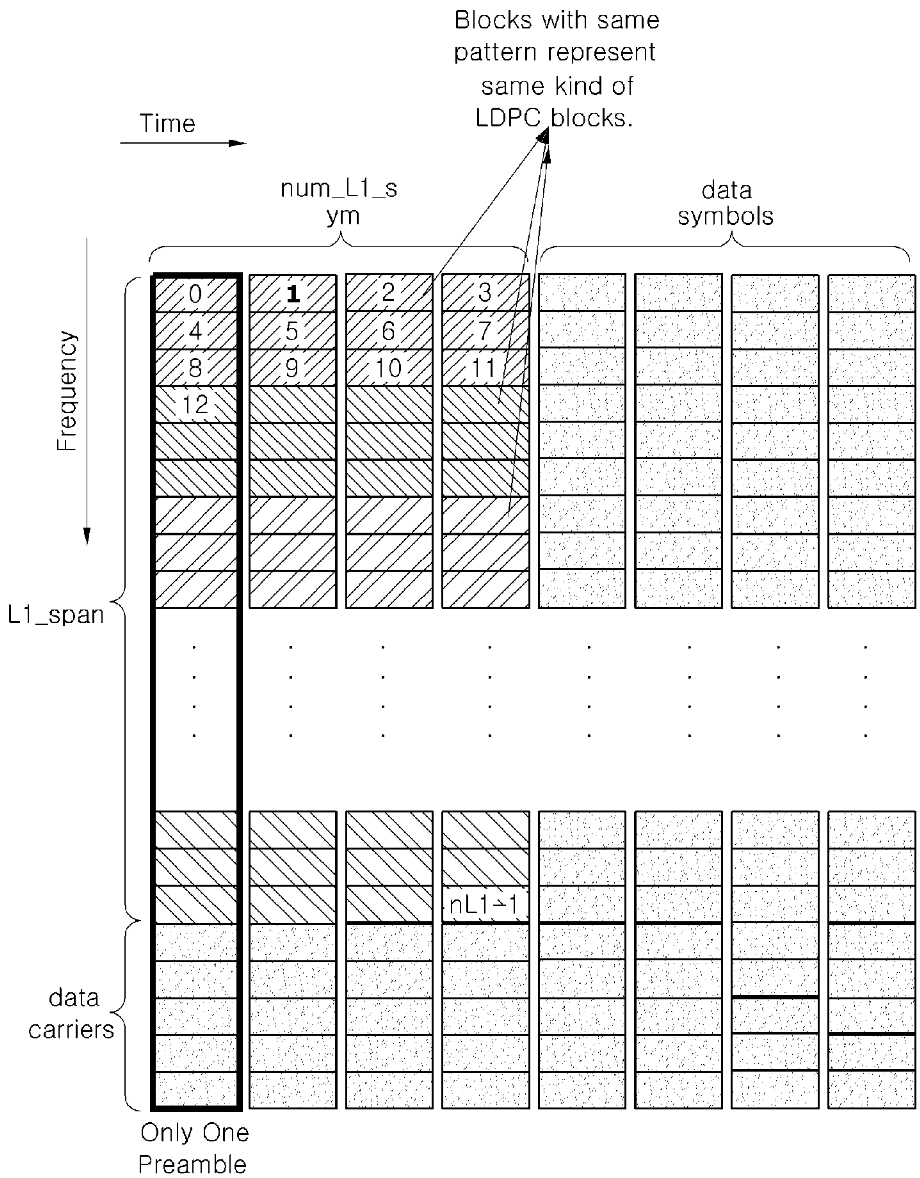


Fig. 73

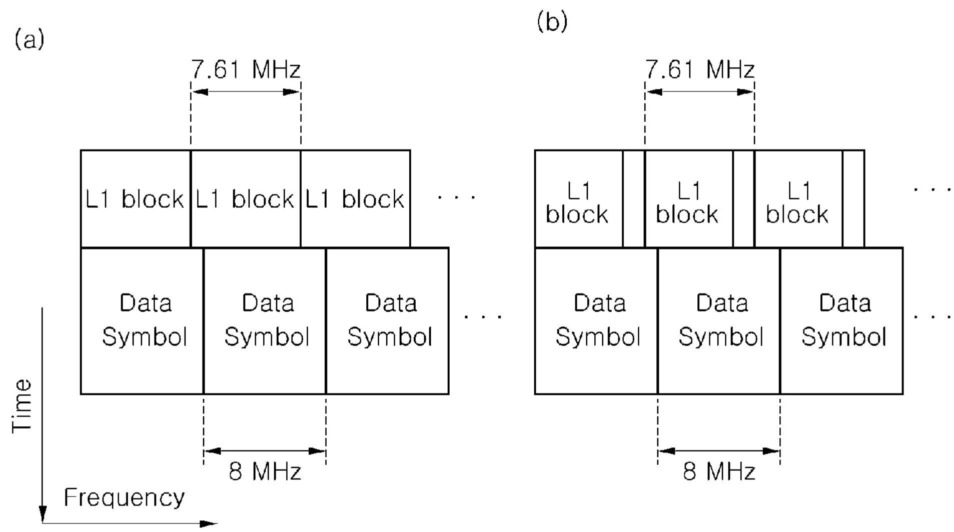
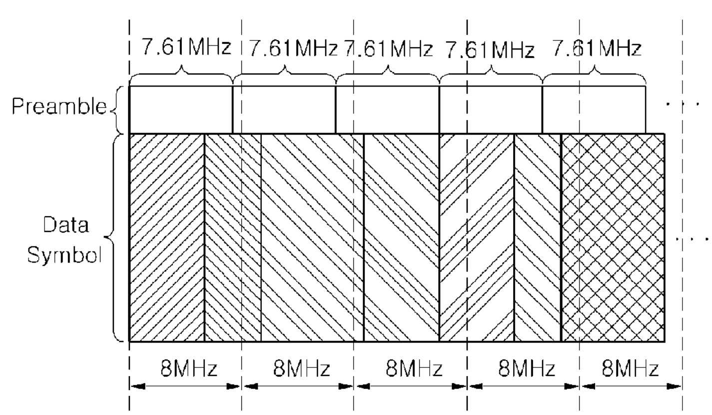

(a)
7.61 MHz
L1 block
L1 block
L1 block
Data Symbol
Data Symbol
Data Symbol
8 MHz
Time
Frequency
(b)
7.61 MHz
L1 block
L1 block
L1 block
Data Symbol
Data Symbol
Data Symbol
8 MHz

Fig. 74

Field	Bits	
L1_column	9	number of carriers spanned by L1 block within one OFDM symbol (Max=7.61 MHz)
L1_row	3	number of OFDM symbols spanned by L1 block
num_chbon	3	number of bonded channels
num_plp	8	number of data slices
num_dslice	8	number of PLPs
num_notch	5	number of notch bands
for dslice {		
chbon_index	3	bonded channel index
dslice_start	9	start of data slice within one channel (8 MHz)
dslice_width	9	width of data slice
}		
for plp {		
dslice_id	8	data sliced ID
plp_id	8	PLP ID
plp_type	1	PLP type (common/data)
plp_payload_type	5	PLP payload type (TS, GS, ...)
}		
for notch {		
chbon_index	3	bonded channel index
notch_start	9	start of notch band within one channel (8 MHz)
notch_width	9	width of notch band
}		
gi	1	guard interval mode
sframe_id	16	superframe ID
frame_id	16	fraem ID
reserved	16	rfu
crc32	32	CRC32
Total	11776	

The number of L1 information bits varies according to various configurations/conditions

Fig. 75



APPARATUS FOR TRANSMITTING AND RECEIVING A SIGNAL AND METHOD OF TRANSMITTING AND RECEIVING A SIGNAL

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 13/941,159, filed Jul. 12, 2013, currently pending, which is a continuation of U.S. application Ser. No. 12/922,682, filed Sep. 14, 2010, now U.S. Pat. No. 8,503,550, which is the National Stage filing under 35 U.S.C. 371 of International Application No. PCT/KR2009/002505, filed on May 12, 2009, which claims priority to U.S. Provisional Application Ser. No. 61/112,158, filed on Nov. 6, 2008, the contents of all of which are incorporated by reference herein in their entireties.

TECHNICAL FIELD

The present invention relates to a method for transmitting and receiving a signal and an apparatus for transmitting and receiving a signal, and more particularly, to a method for transmitting and receiving a signal and an apparatus for transmitting and receiving a signal, which are capable of improving data transmission efficiency.

BACKGROUND ART

As a digital broadcasting technology has been developed, users have received a high definition (HD) moving image. With continuous development of a compression algorithm and high performance of hardware, a better environment will be provided to the users in the future. A digital television (DTV) system can receive a digital broadcasting signal and provide a variety of supplementary services to users as well as a video signal and an audio signal.

Digital Video Broadcasting (DVB)-C2 is the third specification to join DVB's family of second generation transmission systems. Developed in 1994, today DVB-C is deployed in more than 50 million cable tuners worldwide. In line with the other DVB second generation systems, DVB-C2 uses a combination of Low-density parity-check (LDPC) and BCH codes. This powerful Forward Error correction (FEC) provides about 5 dB improvement of carrier-to-noise ratio over DVB-C. Appropriate bit-interleaving schemes optimize the overall robustness of the FEC system. Extended by a header, these frames are called Physical Layer Pipes (PLP). One or more of these PLPs are multiplexed into a data slice. Two dimensional interleaving (in the time and frequency domains) is applied to each slice enabling the receiver to eliminate the impact of burst impairments and frequency selective interference such as single frequency ingress.

DISCLOSURE OF INVENTION

Technical Problem

With the development of these digital broadcasting technologies, a requirement for a service such as a video signal and an audio signal increased and the size of data desired by users or the number of broadcasting channels gradually increased.

Technical Solution

Accordingly, the present invention is directed to a method for transmitting and receiving a signal and an apparatus for

transmitting and receiving a signal that substantially obviate one or more problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide a method of transmitting broadcasting signal to a receiver, comprising: mapping preamble data bits into preamble data symbols and data bits into data symbols; building at least one data slice based on the data symbols; time-interleaving the data symbols at a level of the data slice; building a signal frame based on the preamble data symbols and the data slice, the preamble data symbols comprising Layer 1(L1) signaling information for signaling the data slice; modulating the built signal frame by an Orthogonal Frequency Division Multiplexing (OFDM) method; and transmitting the modulated signal frame.

Another aspect of the present invention provides a method of receiving broadcasting signal, comprising; demodulating the received signal by use of an Orthogonal Frequency Division Multiplexing (OFDM) method; obtaining a signal frame from the demodulated signals, the signal frame comprising preamble symbols and data symbols, wherein the preamble symbols have Layer 1(L1) signaling information, wherein the data symbols are divided into at least one data slices; frequency-deinterleaving the data symbols at a level of the data slice; demapping the time-deinterleaved data symbols into bits; and decoding the bits by LDPC (low density parity check) decoding scheme.

Yet another aspect of the present invention provides a transmitter of transmitting broadcasting signal to a receiver, the transmitter comprising: a mapper configured to map preamble data bits into preamble data symbols and data bits into data symbols; a data slice builder configured to build at least one data slice based on the data symbols; a time-interleaver configured to time-interleave the data symbols at a level of the data slice; a frame builder configured to build a signal frame based on the preamble data symbols and the data slice, the preamble data symbols comprising Layer 1(L1) signaling information for signaling the data slice; a modulator configured to Modulate the built signal frame by an Orthogonal Frequency Division Multiplexing (OFDM) method; and a transmission unit configured to transmit the modulated signal frame.

Yet another aspect of the present invention provides a receiver of receiving broadcasting signal, the receiver comprising: a demodulator configured to demodulate the received signal by use of an Orthogonal Frequency Division Multiplexing (OFDM) method; a frame Parser configured to obtain a signal frame from the demodulated signals, the signal frame comprising preamble symbols and data symbols, wherein the preamble symbols have Layer 1(L1) signaling information, wherein the data symbols are divided into at least one data slice; a frequency-deinterleaver configured to frequency-deinterleave the data symbols at a level of the data slice; a demapper configured to demap the time-deinterleaved data symbols into bits; and a decoder configured to decode the bits by LDPC (Low Density Parity Check) decoding scheme.

BRIEF DESCRIPTION OF DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiment(s) of the invention and together with the description serve to explain the principle of the invention. In the drawings:

FIG. **1** is an example of 64-Quadrature amplitude modulation (QAM) used in European DVB-T.

FIG. **2** is a method of Binary Reflected Gray Code (BRGC).

FIG. **3** is an output close to Gaussian by modifying 64-QAM used in DVB-T.

FIG. **4** is Hamming distance between Reflected pair in BRGC.

FIG. **5** is characteristics in QAM where Reflected pair exists for each I axis and Q axis.

FIG. **6** is a method of modifying QAM using Reflected pair of BRGC.

FIG. **7** is an example of modified 64/256/1024/4096-QAM.

FIGS. **8-9** are an example of modified 64-QAM using Reflected Pair of BRGC.

FIGS. **10-11** are an example of modified 256-QAM using Reflected Pair of BRGC.

FIGS. **12-13** are an example of modified 1024-QAM using Reflected Pair of BRGC (0~511).

FIGS. **14-15** are an example of modified 1024-QAM using Reflected Pair of BRGC (512~1023).

FIGS. **16-17** are an example of modified 4096-QAM using Reflected Pair of BRGC (0~511).

FIGS. **18-19** are an example of modified 4096-QAM using Reflected Pair of BRGC (512~1023).

FIGS. **20-21** are an example of modified 4096-QAM using Reflected Pair of BRGC (1024~1535).

FIGS. **22-23** are an example of modified 4096-QAM using Reflected Pair of BRGC (1536~2047).

FIGS. **24-25** are an example of modified 4096-QAM using Reflected Pair of BRGC (2048~2559).

FIGS. **26-27** are an example of modified 4096-QAM using Reflected Pair of BRGC (2560~3071).

FIGS. **28-29** are an example of modified 4096-QAM using Reflected Pair of BRGC (3072~3583).

FIGS. **30-31** are an example of modified 4096-QAM using Reflected Pair of BRGC (3584~4095).

FIG. **32** is an example of Bit mapping of Modified-QAM where 256-QAM is modified using BRGC.

FIG. **33** is an example of transformation of MQAM into Non-uniform constellation.

FIG. **34** is an example of digital transmission system.

FIG. **35** is an example of an input processor.

FIG. **36** is an information that can be included in Base band (BB).

FIG. **37** is an example of BICM.

FIG. **38** is an example of shortened/punctured encoder.

FIG. **39** is an example of applying various constellations.

FIG. **40** is another example of cases where compatibility between conventional systems is considered.

FIG. **41** is a frame structure which comprises preamble for L1 signaling and data symbol for PLP data.

FIG. **42** is an example of frame builder.

FIG. **43** is an example of pilot insert (**404**) shown in FIG. **4**.

FIG. **44** is a structure of SP.

FIG. **45** is a new SP structure or Pilot Pattern (PP) 5.

FIG. **46** is a suggested PP5' structure.

FIG. **47** is a relationship between data symbol and preamble.

FIG. **48** is another relationship between data symbol and preamble.

FIG. **49** is an example of cable channel delay profile.

FIG. **50** is scattered pilot structure that uses z=56 and z=112.

FIG. **51** is an example of modulator based on OFDM.

FIG. **52** is an example of preamble structure.

FIG. **53** is an example of Preamble decoding.

FIG. **54** is a process for designing more optimized preamble.

FIG. **55** is another example of preamble structure

FIG. **56** is another example of Preamble decoding.

FIG. **57** is an example of Preamble structure.

FIG. **58** is an example of L1 decoding.

FIG. **59** is an example of analog processor.

FIG. **60** is an example of digital receiver system.

FIG. **61** is an example of analog processor used at receiver.

FIG. **62** is an example of demodulator.

FIG. **63** is an example of frame parser.

FIG. **64** is an example of BICM demodulator.

FIG. **65** is an example of LDPC decoding using shortening/puncturing.

FIG. **66** is an example of output processor.

FIG. **67** is an example of L1 block repetition rate of 8 MHz.

FIG. **68** is an example of L1 block repetition rate of 8 MHz.

FIG. **69** is a new L1 block repetition rate of 7.61 MHz.

FIG. **70** is an example of L1 signaling which is transmitted in frame header.

FIG. **71** is preamble and L1 Structure simulation result.

FIG. **72** is an example of symbol interleaver.

FIG. **73** is an example of an L1 block transmission.

FIG. **74** is another example of L1 signaling transmitted within a frame header.

FIG. **75** is an example of frequency or time interleaving/deinterleaving.

BEST MODE FOR CARRYING OUT THE INVENTION

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

In the following description, the term "service" is indicative of either broadcast contents which can be transmitted/received by the signal transmission/reception apparatus.

Quadrature amplitude modulation (QAM) using Binary Reflected Gray Code (BRGC) is used as modulation in a broadcasting transmission environment where conventional Bit Interleaved Coded Modulation (BICM) is used. FIG. **1** shows an example if 64-QAM used in European DVB-T.

BRGC can be made using the method shown in FIG. **2**. An n bit BRGC can be made by adding a reverse code of (n-1) bit BRGC (i.e., reflected code) to a back of (n-1) bit, by adding 0s to a front of original (n-1) bit BRGC, and by adding is to a front of reflected code. The BRGC code made by this method has a Hamming distance between adjacent codes of one (1). In addition, when BRGC is applied to QAM, the Hamming distance between a point and the four points which are most closely adjacent to the point, is one (1) and the Hamming distance between the point and another four points which are second most closely adjacent to the point, is two (2). Such characteristics of Hamming distances between a specific constellation point and other adjacent points can be dubbed as Gray mapping rule in QAM.

To make a system robust against Additive White Gaussian Noise (AWGN), distribution of signals transmitted from a transmitter can be made close to Gaussian distribution. To be able to do that, locations of points in constellation can be modified. FIG. **3** shows an output close to Gaussian by modifying 64-QAM used in DVB-T. Such constellation can be dubbed as Non-uniform QAM (NU-QAM).

To make a constellation of Non-uniform QAM, Gaussian Cumulative Distribution Function (CDF) can be used. In case of 64, 256, or 1024 QAM, i.e., 2^N AMs, QAM can be divided into two independent N-PAM. By dividing Gaussian CDF into N sections of identical probability and by allowing a signal point in each section to represent the section, a constellation having Gaussian distribution can be made. In other words, coordinate xj of newly defined non-uniform N-PAM can be defined as follows:

$$\int_{-\infty}^{x_j} \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} dx = p_j, \quad \text{(Eq. 1)}$$

$$P_j \in \left\{\frac{1}{2N}, \frac{3}{2N}, \dots, \frac{2N-1}{2N}\right\}$$

FIG. **3** is an example of transforming 64 QAM of DVB-T into NU-64 QAM using the above methods. FIG. **3** represents a result of modifying coordinates of each I axis and Q axis using the above methods and mapping the previous constellation points to newly defined coordinates. In case of 32, 128, or 512 QAM, i.e., cross QAM, which is not 2^N QAM, by modifying Pj appropriately, a new coordinate can be found.

One embodiment of the present invention can modify QAM using BRGC by using characteristics of BRGC. As shown in FIG. **4**, the Hamming distance between Reflected pair in BRGC is one because it differs only in one bit which is added to the front of each code. FIG. **5** shows the characteristics in QAM where Reflected pair exists for each I axis and Q axis. In this figure, Reflected pair exists on each side of the dotted black line.

By using Reflected pairs existing in QAM, an average power of a QAM constellation can be lowered while keeping Gray mapping rule in QAM. In other words, in a constellation where an average power is normalized as 1, the minimum Euclidean distance in the constellation can be increased. When this modified QAM is applied to broadcasting or communication systems, it is possible to implement either a more noise-robust system using the same energy as a conventional system or a system with the same performance as a conventional system but which uses less energy.

FIG. **6** shows a method of modifying QAM using Reflected pair of BRGC. FIG. **6***a* shows a constellation and FIG. **6***b* shows a flowchart for modifying QAM using Reflected pair of BRGC. First, a target point which has the highest power among constellation points needs to be found. Candidate points are points where that target point can move and are the closest neighbor points of the target point's reflected pair. Then, an empty point (i.e., a point which is not yet taken by other points) having the smallest power needs to be found among the candidate points and the power of the target point and the power of a candidate point are compared. If the power of the candidate point is smaller, the target point moves to the candidate point. These processes are repeated until an average power of the points on constellation reaches a minimum while keeping Gray mapping rule.

FIG. **7** shows an example of modified 64/256/1024/4096-QAM. The Gray mapped values correspond to FIGS. **8**~**31** respectively. In addition to these examples, other types of modified QAM which enables identical power optimization can be realized. This is because a target point can move to multiple candidate points. The suggested modified QAM can be applied to, not only the 64/256/1024/4096-QAM, but also cross QAM, a bigger size QAM, or modulations using other BRGC other than QAM.

FIG. **32** shows an example of Bit mapping of Modified-QAM where 256-QAM is modified using BRGC. FIG. **32***a* and FIG. **32***b* show mapping of Most Significant Bits (MSB). Points designated as filled circles represent mappings of ones and points designated as blank circles represent mappings of zeros. In a same manner, each bit is mapped as shown in figures from (a) through (h) in FIG. **32**, until Least Significant Bits (LSB) are mapped. As shown in FIG. **32**, Modified-QAM can enable bit decision using only I or Q axes as conventional QAM, except for a bit which is next to MSB (FIG. **32***c* and FIG. **32***d*). By using these characteristics, a simple receiver can be made by partially modifying a receiver for QAM. An efficient receiver can be implemented by checking both I and Q values only when determining bit next to MSB and by calculating only 1 or Q for the rest of bits. This method can be applied to Approximate LLR, Exact LLR, or Hard decision.

By using the Modified-QAM or MQAM, which uses the characteristics of above BRGC, Non-uniform constellation or NU-MQAM can be made. In the above equation where Gaussian CDF is used, Pj can be modified to fit MQAM. Just like QAM, in MQAM, two PAMs having I axis and Q axis can be considered. However, unlike QAM where a number of points corresponding to a value of each PAM axis are identical, the number of points changes in MQAM. If a number of points that corresponds to jth value of PAM is defined as nj in a MQAM where a total of M constellation points exist, then Pj can be defined as follows:

$$\int_{-\infty}^{x_j} \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} dx = P_j \quad \text{(Eq. 2)}$$

$$P_j = \frac{\sum_{i=0}^{i=j-1} n_i + \frac{n_j}{2N}}{M},$$

$$n_0 = 0$$

By using the newly defined Pj, MQAM can be transformed into Non-uniform constellation. Pj can be defined as follows for the example of 256-MQAM.

$$P_j \in \left\{\frac{2.5}{256}, \frac{10}{256}, \frac{22}{256}, \frac{36}{256}, \frac{51}{256}, \frac{67}{256}, \frac{84}{256}, \frac{102}{256}, \frac{119.5}{256}, \frac{136.5}{256}, \frac{154}{256}, \frac{172}{256}, \frac{189}{256}, \frac{205}{256}, \frac{220}{256}, \frac{234}{256}, \frac{246}{256}, \frac{253.5}{256}\right\}$$

FIG. **33** is an example of transformation of MQAM into Non-uniform constellation. The NU-MQAM made using these methods can retain characteristics of MQAM receivers with modified coordinates of each PAM. Thus, an efficient receiver can be implemented. In addition, a more noise-robust system than the previous NU-QAM can be implemented. For a more efficient broadcasting transmission system, hybridizing MQAM and NU-MQAM is possible. In other words, a more noise-robust system can be implemented by using MQAM for an environment where an error correction code with high code rate is used and by using NU-MQAM otherwise. For such a case, a transmitter can let a receiver have information of code rate of an error correction code currently used and a kind of modulation currently used such that the receiver can demodulate according to the modulation currently used.

FIG. **34** shows an example of digital transmission system. Inputs can comprise a number of MPEG-TS streams or GSE (General Stream Encapsulation) streams. An input processor module **101** can add transmission parameters to input stream and perform scheduling for a BICM module **102**. The BICM module **102** can add redundancy and interleave data for transmission channel error correction. A frame builder **103** can build frames by adding physical layer signaling information and pilots. A modulator **104** can perform modulation on input symbols in efficient methods. An analog processor **105** can perform various processes for converting input digital signals into output analog signals.

FIG. **35** shows an example of an input processor. Input MPEG-TS or GSE stream can be transformed by input pre-processor into a total of n streams which will be independently processed. Each of those streams can be either a complete TS frame which includes multiple service components or a minimum TS frame which includes service component (i.e., video or audio). In addition, each of those streams can be a GSE stream which transmits either multiple services or a single service.

Input interface module **202-1** can allocate a number of input bits equal to the maximum data field capacity of a Baseband (BB) frame. A padding may be inserted to complete the LDPC/BCH code block capacity. The input stream sync module **203-1** can provide a mechanism to regenerate, in the receiver, the clock of the Transport Stream (or packetized Generic Stream), in order to guarantee end-to-end constant bit rates and delay.

In order to allow the Transport Stream recombining without requiring additional memory in the receiver, the input Transport Streams are delayed by delay compensators **204-1**~*n* considering interleaving parameters of the data PLPs in a group and the corresponding common PLP. Null packet deleting modules **205-1**~*n* can increase transmission efficiency by removing inserted null packet for a case of VBR (variable bit rate) service. Cyclic Redundancy Check (CRC) encoder modules **206-1**~*n* can add CRC parity to increase transmission reliability of BB frame. BB header inserting modules **207-1**~*n* can add BB frame header at a beginning portion of BB frame. Information that can be included in BB header is shown in FIG. **36**.

A Merger/slicer module **208** can perform BB frame slicing from each PLP, merging BB frames from multiple PLPs, and scheduling each BB frame within a transmission frame. Therefore, the merger/slicer module **208** can output L1 signaling information which relates to allocation of PLP in frame. Lastly, a BB scrambler module **209** can randomize input bitstreams to minimize correlation between bits within bitstreams. The modules in shadow in FIG. **35** are modules used when transmission system uses a single PLP, the other modules in FIG. **35** are modules used when the transmission device uses multiple PLPs.

FIG. **37** shows an example of BICM module. FIG. **37***a* shows data path and FIG. **37***b* shows L1 path of BICM module. An outer coder module **301** and an inner coder module **303** can add redundancy to input bitstreams for error correction. An outer interleaver module **302** and an inner interleaver module **304** can interleave bits to prevent burst error. The Outer interleaver module **302** can be omitted if the BICM is specifically for DVB-C2. A bit demux module **305** can control reliability of each bit output from the inner interleaver module **304**. A symbol mapper module **306** can map input bitstreams into symbol streams. At this time, it is possible to use any of a conventional QAM, an MQAM which uses the aforementioned BRGC for performance improvement, an NU-QAM which uses Non-uniform modulation, or an NU-MQAM which uses Non-uniform modulation applied BRGC for performance improvement. To construct a system which is more robust against noise, combinations of modulations using MQAM and/or NU-MQAM depending on the code rate of the error correction code and the constellation capacity can be considered. At this time, the Symbol mapper module **306** can use a proper constellation according to the code rate and constellation capacity. FIG. **39** shows an example of such combinations.

Case 1 shows an example of using only NU-MQAM at low code rate for simplified system implementation. Case 2 shows an example of using optimized constellation at each code rate. The transmitter can send information about the code rate of the error correction code and the constellation capacity to the receiver such that the receiver can use an appropriate constellation. FIG. **40** shows another example of cases where compatibility between conventional systems is considered. In addition to the examples, further combinations for optimizing the system are possible.

The ModCod Header inserting module **307** shown in FIG. **37** can take Adaptive coding and modulation (ACM)/Variable coding and modulation (VCM) feedback information and add parameter information used in coding and modulation to a FEC block as header. The Modulation type/Coderate (ModCod) header can include the following information:

FEC type (1 bits)-long or short LDPC
Coderate (3 bits)
Modulation (3 bits)-up-to 64K QAM
PLP identifier (8 bits)

The Symbol interleaver module **308** can perform interleaving in symbol domain to obtain additional interleaving effects. Similar processes performed on data path can be performed on L1 signaling path but with possibly different parameters (**301-1**~**308-1**). At this point, a shortened/punctured code module (**303-1**) can be used for inner code.

FIG. **38** shows an example of LDPC encoding using shortening/puncturing. Shortening process can be performed on input blocks which have less bits than a required number of bits for LDPC encoding as many zero bits required for LDPC encoding can be padded (**301***c*). Zero Padded input bitstreams can have parity bits through LDPC encoding (**302***c*). At this time, for bitstreams that correspond to original bitstreams, zeros can be removed (**303***c*) and for parity bitstreams, puncturing (**304***c*) can be performed according to code-rates. These processed information bitstreams and parity bitstreams can be multiplexed into original sequences and outputted (**305***c*).

FIG. **41** shows a frame structure which comprises preamble for L1 signaling and data symbol for PLP data. It can be seen that preamble and data symbols are cyclically generated, using one frame as a unit. Data symbols comprise PLP type 0 which is transmitted using a fixed modulation/coding and PLP type 1 which is transmitted using a variable modulation/coding. For PLP type 0, information such as modulation, FEC type, and FEC code rate are transmitted in preamble (see FIG. **42** Frame header insert **401**). For PLP type 1, corresponding information can be transmitted in FEC block header of a data symbol (see FIG. **37** ModCod header insert **307**). By the separation of PLP types, ModCod overhead can be reduced by 3-4% from a total transmission rate, for PLP type0 which is transmitted at a fixed bit rate. At a receiver, for fixed modulation/coding PLP of PLP type 0, Frame header remover **r401** shown in FIG. **63** can extract information on Modulation and FEC code rate and provide the extracted information to a BICM decoding module. For variable modulation/coding PLP of PLP type 1, ModCod extracting modules, **r307** and **r307-1** shown in FIG. **64** can extract and provide the parameters necessary for BICM decoding.

FIG. **42** shows an example of a frame builder. A frame header inserting module **401** can form a frame from input symbol streams and can add frame header at front of each transmitted frame. The frame header can include the following information:

* Number of bonded channels (4 bits)
* Guard interval (2 bits)
* PAPR (2 bits)
* Pilot pattern (2 bits)
* Digital System identification (16 bits)
* Frame identification (16 bits)
* Frame length (16 bits) number of Orthogonal Frequency Division Multiplexing (OFDM) symbols per frame
* Superframe length (16 bits) number of frames per superframe
* number of PLPs (8 bits)
* for each PLP
PLP identification (8 bits)
Channel bonding id (4 bits)
PLP start (9 bits)
PLP type (2 bits) common PLP or others
PLP payload type (5 bits)
MC type (1 bit) -fixed/variable modulation & coding
if MC type == fixed modulation & coding
FEC type (1 bits) -long or short LDPC
Coderate (3 bits)
Modulation (3 bits) -up-to 64K QAM
end if;
Number of notch channels (2 bits)
for each notch
Notch start (9 bits)
Notch width (9 bits)
end for;
PLP width (9 bits) - max number of FEC blocks of PLP
PLP time interleaving type (2 bits)
end for;
* CRC-32 (32 bits)

Channel bonding environment is assumed for L1 information transmitted in Frame header and data that correspond to each data slice is defined as PLP. Therefore, information such as PLP identifier, channel bonding identifier, and PLP start address are required for each channel used in bonding. One embodiment of this invention suggests transmitting ModCod field in FEC frame header if PLP type supports variable modulation/coding and transmitting ModCod field in Frame header if PLP type supports fixed modulation/coding to reduce signaling overhead. In addition, if a Notch band exists for each PLP, by transmitting the start address of the Notch and its width, decoding corresponding carriers at the receiver can become unnecessary.

FIG. **43** shows an example of Pilot Pattern 5 (PP5) applied in a channel bonding environment. As shown, if SP positions are coincident with preamble pilot positions, irregular pilot structure can occur.

FIG. **43***a* shows an example of pilot inserting module **404** as shown in FIG. **42**. As represented in FIG. **43**, if a single frequency band (for example, 8 MHz) is used, the available bandwidth is 7.61 MHz, but if multiple frequency bands are bonded, guard bands can be removed, thus, frequency efficiency can increase greatly. FIG. **43***b* is an example of preamble inserting module **504** as shown in FIG. **51** that is transmitted at the front part of the frame and even with channel bonding, the preamble has repetition rate of 7.61 MHz, which is bandwidth of L1 block. This is a structure considering the bandwidth of a tuner which performs initial channel scanning.

Pilot Patterns exist for both Preamble and Data Symbols. For data symbol, scattered pilot (SP) patterns can be used. Pilot Pattern 5 (PP5) and Pilot Pattern 7 (PP7) of T2 can be good candidates for frequency-only interpolation. PP5 has x=12, y=4, z=48 for GI=1/64 and PP7 has x=24, y=4, z=96 for GI=1/128. Additional time-interpolation is also possible for a better channel estimation. Pilot patterns for preamble can cover all possible pilot positions for initial channel acquisition. In addition, preamble pilot positions should be coincident with SP positions and a single pilot pattern for both the preamble and the SP is desired. Preamble pilots could also be used for time-interpolation and every preamble could have an identical pilot pattern. These requirements are important for C2 detection in scanning and necessary for frequency offset estimation with scrambling sequence correlation. In a channel bonding environment, the coincidence in pilot positions should also be kept for channel bonding because irregular pilot structure may degrade interpolation performance.

In detail, if a distance z between scattered pilots (SPs) in an OFDM symbol is 48 and if a distance y between SPs corresponding to a specific SP carrier along the time axis is 4, an effective distance x after time interpolation becomes 12. This is when a guard interval (GI) fraction is 1/64. If GI fraction is 1/128, x=24, y=4, and z=96 can be used. If channel bonding is used, SP positions can be made coincident with preamble pilot positions by generating non-continuous points in scattered pilot structure.

At this time, preamble pilot positions can be coincident with every SP positions of data symbol. When channel bonding is used, data slice where a service is transmitted, can be determined regardless of 8 MHz bandwidth granularity. However, for reducing overhead for data slice addressing, transmission starting from SP position and ending at SP position can be chosen.

When a receiver receives such SPs, if necessary, channel estimation module **r501** shown in FIG. **62** can perform time interpolation to obtain pilots shown in dotted lines in FIG. **43** and perform frequency interpolation. At this time, for non-continuous points of which intervals are designated as 32 in FIG. **43**, either performing interpolations on left and right separately or performing interpolations on only one side then performing interpolation on the other side by using the already interpolated pilot positions of which interval is 12 as a reference point can be implemented. At this time, data slice width can vary within 7.61 MHz, thus, a receiver can minimize power consumption by performing channel estimation and decoding only necessary subcarriers.

FIG. **44** shows another example of PP5 applied in channel bonding environment or a structure of SP for maintaining effective distance x as 12 to avoid irregular SP structure shown in FIG. **43** when channel bonding is used. FIG. **44***a* is a structure of SP for data symbol and FIG. **44***b* is a structure of SP for preamble symbol.

As shown, if SP distance is kept consistent in case of channel bonding, there will be no problem in frequency interpolation but pilot positions between data symbol and preamble may not be coincident. In other words, this structure does not require additional channel estimation for an irregular SP structure, however, SP positions used in channel bonding and preamble pilot positions become different for each channel.

FIG. **45** shows a new SP structure or PP5 to provide a solution to the two problems aforementioned in channel bonding environment. Specifically, a pilot distance of x=16 can solve those problems. To preserve pilot density or to maintain the same overhead, a PP5' can have x=16, y=3, z=48 for GI=1/64 and a PP7' can have x=16, y=6, z=96 for GI=1/128. Frequency-only interpolation capability can still be maintained. Pilot positions are depicted in FIG. **45** for comparison with PP5 structure.

FIG. **46** shows an example of a new SP Pattern or PP5 structure in channel bonding environment. As shown in FIG. **46**, whether either single channel or channel bonding is used, an effective pilot distance x=16 can be provided. In addition, because SP positions can be made coincident with preamble pilot positions, channel estimation deterioration caused by SP irregularity or non-coincident SP positions can be avoided. In other words, no irregular SP position exists for freq-interpolator and coincidence between preamble and SP positions is provided.

Consequently, the proposed new SP patterns can be advantageous in that single SP pattern can be used for both single and bonded channel; no irregular pilot structure can be caused, thus a good channel estimation is possible; both preamble and SP pilot positions can be kept coincident; pilot density can be kept the same as for PP5 and PP7 respectively; and Frequency-only interpolation capability can also be preserved.

In addition, the preamble structure can meet the requirements such as preamble pilot positions should cover all possible SP positions for initial channel acquisition; maximum number of carriers should be 3409 (7.61 MHz) for initial scanning; exactly same pilot patterns and scrambling sequence should be used for C2 detection; and no detection-specific preamble like P1 in T2 is required.

In terms of relation with frame structure, data slice position granularity may be modified to 16 carriers rather than 12, thus, less position addressing overhead can occur and no other problem regarding data slice condition, Null slot condition etc can be expected.

Therefore, at channel estimation module **r501** of FIG. **62**, pilots in every preamble can be used when time interpolation of SP of data symbol is performed. Therefore, channel acquisition and channel estimation at the frame boundaries can be improved.

Now, regarding requirements related to the preamble and the pilot structure, there is consensus in that positions of preamble pilots and SPs should coincide regardless of channel bonding; the number of total carriers in L1 block should be dividable by pilot distance to avoid irregular structure at band edge; L1 blocks should be repeated in frequency domain; and L1 blocks should always be decodable in arbitrary tuner window position. Additional requirements would be that pilot positions and patterns should be repeated by period of 8 MHz; correct carrier frequency offset should be estimated without channel bonding knowledge; and L1 decoding (re-ordering) is impossible before the frequency offset is compensated.

FIG. **47** shows a relationship between data symbol and preamble when preamble structures as shown in FIG. **52** and FIG. **53** are used. L1 block can be repeated by period of 6 MHz. For L1 decoding, both frequency offset and Preamble shift pattern should be found. L1 decoding is not possible in arbitrary tuner position without channel bonding information and a receiver cannot differentiate between preamble shift value and frequency offset.

Thus, a receiver, specifically for Frame header remover **r401** shown in FIG. **63** to perform L1 signal decoding, channel bonding structure needs to be obtained. Because preamble shift amount expected at two vertically shadowed regions in FIG. **47** is known, time/freq synchronizing module **r505** in FIG. **62** can estimate carrier frequency offset. Based on the estimation, L1 signaling path (**r308-1**~**r301-1**) in FIG. **64** can decode L1.

FIG. **48** shows a relationship between data symbol and preamble when the preamble structure as shown in FIG. **55** is used. L1 block can be repeated by period of 8 MHz. For L1 decoding, only frequency offset needs to be found and channel bonding knowledge may not be required. Frequency offset can be easily estimated by using known Pseudo Random Binary Sequence (PRBS) sequence. As shown in FIG. **48**, preamble and data symbols are aligned, thus, additional sync search can become unnecessary. Therefore, for a receiver, specifically for the Frame header remover module **r401** shown in FIG. **63**, it is possible that only correlation peak with pilot scrambling sequence needs to be obtained to perform L1 signal decoding. The time/freq synchronizing module **r505** in FIG. **62** can estimate carrier frequency offset from peak position.

FIG. **49** shows an example of cable channel delay profile.

From the point of view of pilot design, current GI already over-protects delay spread of cable channel. In the worst case, redesigning the channel model can be an option. To repeat the pattern exactly every 8 MHz, the pilot distance should be a divisor of 3584 carriers (z=32 or 56). A pilot density of z=32 can increase pilot overhead, thus, z=56 can be chosen. Slightly less delay coverage may not be an important in cable channel. For example, it can be 8 μs for PP5' and 4 μs for PP7' compared to 9.3 μs (PP5) and 4.7 μs (PP7). Meaningful delays can be covered by both pilot patterns even in a worst case. For preamble pilot position, no more than all SP positions in data symbol are necessary.

If the −40 dB delay path can be ignored, actual delay spread can become 2.5 us, 1/64 GI=7 μs, or 1/128 GI=3.5 μs. This shows that pilot distance parameter, z=56 can be a good enough value. In addition, z=56 can be a convenient value for structuring pilot pattern that enables preamble structure shown in FIG. **48**.

FIG. **50** shows scattered pilot structure that uses z=56 and z=112 which is constructed at pilot inserting module **404** in FIG. **42**. PP5' (x=14, y=4, z=56) and PP7' (x=28, y=4, z=112) are proposed. Edge carriers could be inserted for closing edge.

As shown in FIG. **50**, pilots are aligned at 8 MHz from each edge of the band, every pilot position and pilot structure can be repeated every 8 MHz. Thus, this structure can support the preamble structure shown in FIG. **48**. In addition, a common pilot structure between preamble and data symbols can be used. Therefore, channel estimation module **r501** in FIG. **62** can perform channel estimation using interpolation on preamble and data symbols because no irregular pilot pattern can occur, regardless of window position which is decided by data slice locations. At this time, using only frequency interpolation can be enough to compensate channel distortion from delay spread. If time interpolation is performed additionally, more accurate channel estimation can be performed.

Consequently, in the new proposed pilot pattern, pilot position and pattern can be repeated based on a period of 8 MHz. A single pilot pattern can be used for both preamble and data symbols. L1 decoding can always be possible without channel bonding knowledge. In addition, the proposed pilot pattern may not affect commonality with T2 because the same pilot strategy of scattered pilot pattern can be used; T2 already uses 8 different pilot patterns; and no significant receiver complexity can be increased by modified pilot patterns. For a pilot scrambling sequence, the period of PRBS can be 2047 (m-sequence); PRBS generation can be reset every 8 MHz, of which the period is 3584; pilot repetition rate of 56 can be also co-prime with 2047; and no PAPR issue can be expected.

FIG. **51** shows an example of a modulator based on OFDM. Input symbol streams can be transformed into time domain by IFFT module **501**. If necessary, peak-to-average power ratio (PAPR) can be reduced at PAPR reducing module **502**. For PAPR methods, Active constellation extension (ACE) or tone reservation can be used. GI inserting module **503** can copy a last part of effective OFDM symbol to fill guard interval in a form of cyclic prefix.

Preamble inserting module **504** can insert preamble at the front of each transmitted frame such that a receiver can detect digital signal, frame and acquire time/freq offset acquisition. At this time, the preamble signal can perform physical layer signaling such as FFT size (3 bits) and Guard interval size (3 bits). The Preamble inserting module **504** can be omitted if the modulator is specifically for DVB-C2.

FIG. **52** shows an example of a preamble structure for channel bonding, generated at preamble inserting module **504** in FIG. **51**. One complete L1 block should be "always decodable" in any arbitrary 7.61 MHz tuning window position and no loss of L1 signaling regardless of tuner window position should occur. As shown, L1 blocks can be repeated in frequency domain by period of 6 MHz. Data symbol can be channel bonded for every 8 MHz. If, for L1 decoding, a receiver uses a tuner such as the tuner **r603** represented in FIG. **61** which uses a bandwidth of 7.61 MHz, the Frame header remover **r401** in FIG. **63** needs to rearrange the received cyclic shifted L1 block (FIG. **53**) to its original form. This rearrangement is possible because L1 block is repeated for every 6 MHz block. FIG. **53***a* can be reordered into FIG. **53***b*.

FIG. **54** shows a process for designing a more optimized preamble. The preamble structure of FIG. **52** uses only 6 MHz of total tuner bandwidth 7.61 MHz for L1 decoding. In terms of spectrum efficiency, tuner bandwidth of 7.61 MHz is not fully utilized. Therefore, there can be further optimization in spectrum efficiency.

FIG. **55** shows another example of preamble structure or preamble symbols structure for full spectrum efficiency, generated at Frame Header Inserting module **401** in FIG. **42**. Just like data symbol, L1 blocks can be repeated in frequency domain by period of 8 MHz. One complete L1 block is still "always decodable" in any arbitrary 7.61 MHz tuning window position. After tuning, the 7.61 MHz data can be regarded as a virtually punctured code. Having exactly the same bandwidth for both the preamble and data symbols and exactly the same pilot structure for both the preamble and data symbols can maximize spectrum efficiency. Other features such as cyclic shifted property and not sending L1 block in case of no data slice can be kept unchanged. In other words, the bandwidth of preamble symbols can be identical with the bandwidth of data symbols or, as shown in FIG. **57**, the bandwidth of the preamble symbols can be the bandwidth of the tuner (here, it's 7.61 MHz). The tuner bandwidth can be defined as a bandwidth that corresponds to a number of total active carriers when a single channel is used. That is, the bandwidth of the preamble symbol can correspond to the number of total active carriers (here, it's 7.61 MHz).

FIG. **56** shows a virtually punctured code. The 7.61 MHz data among the 8 MHz L1 block can be considered as punctured coded. When a tuner **r603** shown in FIG. **61** uses 7.61 MHz bandwidth for L1 decoding, Frame header remover **r401** in FIG. **63** needs to rearrange received, cyclic shifted L1 block into original form as shown in FIG. **56**. At this time, L1 decoding is performed using the entire bandwidth of the tuner. Once the L1 block is rearranged, a spectrum of the rearranged L1 block can have a blank region within the spectrum as shown in upper right side of FIG. **56** because an original size of L1 block is 8 MHz bandwidth.

Once the blank region is zero padded, either after deinterleaving in symbol domain by the freq. deinterleaver **r403** in FIG. **63** or by the symbol deinterleaver **r308-1** in FIG. **64** or after deinterleaving in bit domain by the symbol demapper **r306-1**, bit mux **r305-1**, and inner deinterleaver **r304-1** in FIG. **64**, the block can have a form which appears to be punctured as shown in lower right side of FIG. **56**.

This L1 block can be decoded at the punctured/shortened decode module **r303-1** in FIG. **64**. By using these preamble structure, the entire tuner bandwidth can be utilized, thus spectrum efficiency and coding gain can be increased. In addition, an identical bandwidth and pilot structure can be used for the preamble and data symbols.

In addition, if the preamble bandwidth or the preamble symbols bandwidth is set as a tuner bandwidth as shown in FIG. **58**, (it's 7.61 MHz in the example), a complete L1 block can be obtained after rearrangement even without puncturing. In other words, for a frame having preamble symbols, wherein the preamble symbols have at least one layer 1 (L1) block, it can be said, the L1 block has 3408 active subcarriers and the 3408 active subcarriers correspond to 7.61 MHz of 8 MHz Radio Frequency (RF) band.

Thus, spectrum efficiency and L1 decoding performance can be maximized. In other words, at a receiver, decoding can be performed at punctured/shortened decode module **r303-1** in FIG. **64**, after performing only deinterleaving in the symbol domain.

Consequently, the proposed new preamble structure can be advantageous in that it's fully compatible with previously used preamble except that the bandwidth is different; L1 blocks are repeated by period of 8 MHz; L1 block can be always decodable regardless of tuner window position; Full tuner bandwidth can be used for L1 decoding; maximum spectrum efficiency can guarantee more coding gain; incomplete L1 block can be considered as punctured coded; simple and same pilot structure can be used for both preamble and data; and identical bandwidth can be used for both preamble and data.

FIG. **59** shows an example of an analog processor. A DAC module **601** can convert digital signal input into analog signal. After transmission frequency bandwidth is up-converted (**602**) and analog filtered (**603**) signal can be transmitted.

FIG. **60** shows an example of a digital receiver system. Received signal is converted into digital signal at an analog process module **r105**. A demodulator **r104** can convert the signal into data in frequency domain. A frame parser **r103** can remove pilots and headers and enable selection of service information that needs to be decoded. A BICM demodulator **r102** can correct errors in the transmission channel. An output processor **r101** can restore the originally transmitted service stream and timing information.

FIG. **61** shows an example of analog processor used at the receiver. A Tuner/AGC module **r603** can select desired frequency bandwidth from received signal. A down converting module **r602** can restore baseband. An ADC module **r601** can convert analog signal into digital signal.

FIG. **62** shows an example of demodulator. A frame detecting module **r506** can detect the preamble, check if a corresponding digital signal exists, and detect a start of a frame. A time/freq synchronizing module **r505** can perform synchronization in time and frequency domains. At this time, for time domain synchronization, a guard interval correlation can be used. For frequency domain synchronization, correlation can be used or offset can be estimated from phase information of a subcarrier that is transmitted in the frequency domain. A preamble removing module **r504** can remove preamble from the front of detected frame. A GI removing module **r503** can remove guard interval. A FFT module **r501** can transform signal in the time domain into signal in the frequency domain. A channel estimation/equalization module **r501** can compensate errors by estimating distortion in transmission channel using pilot symbol. The Preamble removing module **r504** can be omitted if the demodulator is specifically for DVB-C2.

FIG. **63** shows an example of frame parser. A pilot removing module **r404** can remove pilot symbol. A freq deinterleaving module **r403** can perform deinterleaving in the frequency domain. An OFDM symbol merger **r402** can restore data frame from symbol streams transmitted in OFDM symbols. A frame header removing module **r401** can extract physical layer signaling from header of each transmitted frame and remove header. Extracted information can be used as parameters for following processes in the receiver.

FIG. **64** shows an example of a BICM demodulator. FIG. **64***a* shows a data path and FIG. **64***b* shows a L1 signaling path. A symbol deinterleaver r**308** can perform deinterleaving in the symbol domain. A ModCod extract **r307** can extract ModCod parameters from front of each BB frame and make the parameters available for following adaptive/variable demodulation and decoding processes. A Symbol demapper r**306** can demap input symbol streams into bit Log-Likelyhood Ratio (LLR) streams. The Output bit LLR streams can be calculated by using a constellation used in a Symbol mapper **306** of the transmitter as reference point. At this point, when the aforementioned MQAM or NU-MQAM is used, by calculating both I axis and Q axis when calculating bit nearest from MSB and by calculating either I axis or Q axis when calculating the rest bits, an efficient symbol demapper can be implemented. This method can be applied to, for example, Approximate LLR, Exact LLR, or Hard decision.

When an optimized constellation according to constellation capacity and code rate of error correction code at the Symbol mapper **306** of the transmitter is used, the Symbol demapper r**306** of the receiver can obtain a constellation using the code rate and constellation capacity information transmitted from the transmitter. The bit mux r**305** of the receiver can perform an inverse function of the bit demux **305** of the transmitter. The Inner deinterleaver r**304** and outer deinterleaver r**302** of the receiver can perform inverse functions of the inner interleaver **304** and outer interleaver **302** of the transmitter, respectively to get the bitstream in its original sequence. The outer deinterleaver r**302** can be omitted if the BICM demodulator is specifically for DVB-C2.

The inner decoder **r303** and outer decoder r**301** of the receiver can perform corresponding decoding processes to the inner coder **303** and outer code **301** of the transmitter, respectively, to correct errors in the transmission channel. Similar processes performed on data path can be performed on L1 signaling path, but with different parameters (**r308-1**~r**301-1**). At this point, as explained in the preamble part, a shortened/punctured code module r**303-1** can be used for L1 signal decoding.

FIG. **65** shows an example of LDPC decoding using shortening/puncturing. A demux **r301***a* can separately output information part and parity part of systematic code from input bit streams. For the information part, a zero padding (**r302***a*) can be performed according to a number of input bit streams of LDPC decoder, for the parity part, input bit streams for (r**303***a*) the LDPC decoder can be generated by depuncturing punctured part. LDPC decoding (r**304***a*) can be performed on generated bit streams, zeros in information part can be removed and output (r**305***a*).

FIG. **66** shows an example of output processor. A BB descrambler **r209** can restore scrambled (**209**) bit streams at the transmitter. A Splitter **r208** can restore BB frames that correspond to multiple PLP that are multiplexed and transmitted from the transmitter according to PLP path. For each PLP path, a BB header remover **r207-1**~*n* can remove the header that is transmitted at the front of the BB frame. A CRC decoder **r206-1**~*n* can perform CRC decoding and make reliable BB frames available for selection. A Null packet inserting modules **r205-1**~*n* can restore null packets which were removed for higher transmission efficiency in their original location. A Delay recovering modules **r204-1**~*n* can restore a delay that exists between each PLP path.

An output clock recovering modules **r203-1**~*n* can restore the original timing of the service stream from timing information transmitted from the input stream synchronization modules **203-1**~*n*. An output interface modules **r202-1**~*n* can restore data in TS/GS packet from input bit streams that are sliced in BB frame. An output postprocess modules **r201-1**~*n* can restore multiple TS/GS streams into a complete TS/GS stream, if necessary. The shaded blocks shown in FIG. **66** represent modules that can be used when a single PLP is processed at a time and the rest of the blocks represent modules that can be used when multiple PLPs are processed at the same time.

Preamble pilot patterns were carefully designed to avoid PAPR increase, thus, whether L1 repetition rate may increase PAPR needs to be considered. The number of L1 information bits varies dynamically according to the channel bonding, the number of PLPs, etc. In detail, it is necessary to consider things such as fixed L1 block size may introduce unnecessary overhead; L1 signaling should be protected more strongly than data symbols; and time interleaving of L1 block can improve robustness over channel impairment such as impulsive noise need.

For a L1 block repetition rate of 8 MHz, as shown in FIG. **67**, full spectrum efficiency (26.8% BW increase) is exhibited with virtual puncturing but the PAPR may be increased since L1 bandwidth is the same as that of the data symbols. For the repetition rate of 8 MHz, 4K-FFT DVB-T2 frequency interleaving can be used for commonality and the same pattern can repeat itself at a 8 MHz period after interleaving.

For a L1 block repetition rate of 6 MHz, as shown in FIG. **68**, reduced spectrum efficiency can be exhibited with no virtual puncturing. A similar problem of PAPR as for the 8 MHz case can occur since the L1 and data symbol bandwidths share LCM=24 MHz. For the repetition rate of 6 MHz, 4K-FFT DVB-T2 frequency interleaving can be used for commonality and the same pattern can repeat itself at a period of 24 MHz after interleaving.

FIG. **69** shows a new L1 block repetition rate of 7.61 MHz or full tuner bandwidth. A full spectrum efficiency (26.8% BW increase) can be obtained with no virtual puncturing. There can be no PAPR issue since L1 and data symbol bandwidths share LCM≈1704 MHz. For the repetition rate of 7.61 MHz, 4K-FFT DVB-T2 frequency interleaving can be used for commonality and the same pattern can repeat itself by period of about 1704 MHz after interleaving.

FIG. **70** is an example of L1 signaling which is transmitted in the frame header. Each information in L1 signaling can be transmitted to the receiver and can be used as a decoding parameter. Especially, the information can be used in L1 signal path shown in FIG. **64** and PLPs can be transmitted in each data slice. An increased robustness for each PLP can be obtained.

FIG. **72** is an example of a symbol interleaver **308-1** as shown in L1 signaling path in

FIG. **37** and also can be an example of its corresponding symbol deinterleaver **r308-1** as shown in L1 signaling path in FIG. **64**. Blocks with tilted lines represent L1 blocks and solid blocks represent data carriers. L1 blocks can be transmitted not only within a single preamble, but also can be transmitted within multiple OFDM blocks. Depending on a size of L1 block, the size of the interleaving block can vary. In other words, num_L1_sym and L1 span can be different from each other. To minimize unnecessary overhead, data can be transmitted within the rest of the carriers of the OFDM symbols where the L1 block is transmitted. At this point, full spectrum efficiency can be guaranteed because the repeating cycle of

L1 block is still a full tuner bandwidth. In FIG. **72**, the numbers in blocks with tilted lines represent the bit order within a single LDPC block.

Consequently, when bits are written in an interleaving memory in the row direction according to a symbol index as shown in FIG. **72** and read in the column direction according to a carrier index, a block interleaving effect can be obtained. In other words, one LDPC block can be interleaved in the time domain and the frequency domain and then can be transmitted. Num_L1_sym can be a predetermined value, for example, a number between 2~4 can be set as a number of OFDM symbols. At this point, to increase the granularity of the L1 block size, a punctured/shortened LDPC code having a minimum length of the codeword can be used for L1 protection.

FIG. **73** is an example of an L1 block transmission. FIG. **73** illustrates FIG. **72** in frame domain. As shown on FIG. **73***a*, L1 blocks can be spanning in full tuner bandwidth or as shown on FIG. **73***b*, L1 blocks can be partially spanned and the rest of the carriers can be used for data carrier. In either case, it can be seen that the repetition rate of L1 block can be identical to a full tuner bandwidth. In addition, for OFDM symbols which uses L1 signaling including preamble, only symbol interleaving can be performed while not allowing data transmission in that OFDM symbols. Consequently, for OFDM symbol used for L1 signaling, a receiver can decode L1 by performing deinterleaving without data decoding. At this point, the L1 block can transmit L1 signaling of current frame or L1 signaling of a subsequent frame. At the receiver side, L1 parameters decoded from L1 signaling decoding path shown in FIG. **64** can be used for decoding process for data path from frame parser of subsequent frame.

In summary, at a transmitter, interleaving blocks of L1 region can be performed by writing blocks to a memory in a row direction and reading the written blocks from the memory in a column direction. At a receiver, deinterleaving blocks of L1 region can be performed by writing blocks to a memory in a column direction and reading the written blocks from the memory in a row direction. The reading and writing directions of transmitter and receiver can be interchanged.

When simulation is performed with assumptions such as CR=½ for L1 protection and for T2 commonality; 16-QAM symbol mapping; pilot density of 6 in the Preamble; number of short LDPC implies required amount of puncturing/shortening are made, results or conclusions such as only preamble for L1 transmission may not be sufficient; the number of OFDM symbols depends on the amount of L1 block size; shortest LDPC codeword (e.g. 192 bits information) among shortened/punctured code may be used for flexibility and fine granularity; and Padding may be added if required with negligible overhead, can be obtained. The result is summarized in FIG. **71**.

Consequently, for a L1 block repetition rate, full tuner bandwidth with no virtual puncturing can be a good solution and still no PAPR issue can arise with full spectrum efficiency. For L1 signaling, efficient signaling structure can allow maximum configuration in an environment of 8 channels bonding, 32 notches, 256 data slices, and 256 PLPs. For L1 block structure, flexible L1 signaling can be implemented according to L1 block size. Time interleaving can be performed for better robustness for T2 commonality. Less overhead can allow data transmission in preamble.

Block interleaving of L1 block can be performed for better robustness. The interleaving can be performed with fixed pre-defined number of L1 symbols (num_L1_sym) and a number of carriers spanned by L1 as a parameter (L1_span). The same technique is used for P2 preamble interleaving in DVB-T2.

L1 block of variable size can be used. Size can be adaptable to the amount of L1 signaling bits, resulting in a reduced overhead. Full spectrum efficiency can be obtained with no PAPR issue. Less than 7.61 MHz repetition can mean that more redundancy can be sent but unused. No PAPR issue can arise because of 7.61 MHz repetition rate for L1 block.

FIG. **74** is another example of L1 signaling transmitted within a frame header. This FIG. **74** is different from FIG. **70** in that the L1_span field having 12 bits it is divided into two fields. In other words, the L1_span field is divided into a L1_column having 9 bits and a L1_row having 3 bits. The L1_column represents the carrier index that L1 spans. Because data slice starts and ends at every 12 carriers, which is the pilot density, the 12 bits of overhead can be reduced by 3 bits to reach 9 bits.

L1_row represents the number of OFDM symbols where L1 is spanning when time interleaving is applied. Consequently, time interleaving can be performed within an area of L1_columns multiplied by L1_rows. Alternatively, a total size of L1 blocks can be transmitted such that L1_span shown in FIG. **70** can be used when time interleaving is not performed. For such a case, L1 block size is 11,776×2 bits in the example, thus 15 bits is enough. Consequently, the L1_span field can be made up of 15 bits.

FIG. **75** is an example of frequency or time interleaving/deinterleaving. The FIG. **75** shows a part of a whole transmission frame. The FIG. **75** also shows bonding of multiple 8 MHz bandwidths. A frame can consist of a preamble which transmits L1 blocks and a data symbol which transmits data. The different kinds of data symbols represent data slices for different services. As shown in FIG. **75**, the preamble transmits L1 blocks for every 7.61 MHz.

For the preamble, frequency or time interleaving is performed within L1 blocks and not performed between L1 blocks. That is, for the preamble, it can be said that interleaving is performed at L1 block level. This allows decoding the L1 blocks by transmitting L1 blocks within a tuner window bandwidth even when the tuner window has moved to a random location within a channel bonding system.

For decoding data symbol at a random tuner window bandwidth, interleaving between data slices should not occur. That is, for data slices, it can be said that interleaving is performed at data slice level. Consequently, frequency interleaving and time interleaving should be performed within a data slice. Therefore, a symbol interleaver **308** in a data path of a BICM module of transmitter as shown in FIG. **37** can perform symbol interleaving for each data slice. A symbol interleaver **308-1** in an L1 signal path can perform symbol interleaving for each L1 block.

A frequency interleaver **403** shown in FIG. **42** needs to perform interleaving on the preamble and data symbols separately. Specifically, for the preamble, frequency interleaving can be performed for each L1 block and for data symbol, frequency interleaving can be performed for each data slice. At this point, time interleaving in data path or L1 signal path may not be performed considering low latency mode.

Using the suggested methods and devices, among others advantages it is possible to implement an efficient digital transmitter, receiver and structure of physical layer signaling.

By transmitting ModCod information in each BB frame header that is necessary for ACM/VCM and transmitting the rest of the physical layer signaling in a frame header, signaling overhead can be minimized.

Modified QAM for a more energy efficient transmission or a more noise-robust digital broadcasting system can be implemented. The system can include transmitter and receiver for each example disclosed and the combinations thereof.

An Improved Non-uniform QAM for a more energy efficient transmission or a more noise-robust digital broadcasting system can be implemented. A method of using code rate of error correction code of NU-MQAM and MQAM is also described. The system can include transmitter and receiver for each example disclosed and the combinations thereof.

The suggested L1 signaling method can reduce overhead by 3-4% by minimizing signaling overhead during channel bonding.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the invention.

The invention claimed is:

1. A method for transmitting broadcast signals, the method comprising:

processing input streams in order to output PLP (Physical Layer Pipe) data corresponding to PLPs;

encoding preamble data carrying L1 (Layer 1) signaling information including channel bonding information for the PLP data;

encoding the PLP data by an LDPC scheme;

QAM (Quadrature Amplitude Modulation) mapping the encoded PLP data;

time interleaving the mapped PLP data;

building signal frames, wherein at least one signal frame includes the encoded preamble data and data symbols including the time interleaved PLP data;

modulating the built signal frame by an Orthogonal Frequency Division Multiplexing (OFDM) method; and

transmitting the modulated signal frame.

2. The method of claim **1**, wherein the L1 signaling information includes type information of the PLPs, wherein the type information indicates a type of each PLP.

3. An apparatus for transmitting broadcast signals, the apparatus comprising:

an input processor to process input streams in order to output PLP (Physical Layer Pipe) data corresponding to PLPs;

a preamble encoder to encode preamble data carrying L1 (Layer 1) signaling information including channel bonding information for the PLP data;

an encoder to encode the PLP data by an LDPC scheme;

a mapper to QAM (Quadrature Amplitude Modulation) map the encoded PLP data;

a time interleaver to time interleave the mapped PLP data;

a builder to build signal frames, wherein at least one signal frame includes the encoded preamble data and data symbols including the time interleaved PLP data;

a modulator to modulate the built signal frame by an Orthogonal Frequency Division Multiplexing (OFDM) method; and

a transmitter to transmit the modulated signal frame.

4. The apparatus of claim **3**, wherein the L1 signaling information includes type information of the PLPs, wherein the type information indicates a type of each PLP.

5. A method for receiving broadcast signals, the method comprising:

receiving the broadcast signals;

demodulating the received broadcast signals by an Orthogonal Frequency Division Multiplexing (OFDM) method;

obtaining signal frames from the demodulated broadcast signals, wherein at least one signal frame includes preamble data and data symbols including PLP (Physical Layer Pipe) data corresponding to PLPs, wherein the preamble data carries L1 (Layer 1) signaling information including channel bonding information for the PLP data;

time deinterleaving the PLP data;

QAM (Quadrature Amplitude Modulation) demapping the time deinterleaved PLP data;

decoding the demapped PLP data;

decoding the preamble data; and

output processing the decoded PLP data.

6. The method of claim **5**, wherein the L1 signaling information includes type information of the PLPs, wherein the type information indicates a type of each PLP.

7. An apparatus for receiving broadcast signals, the apparatus comprising:

a receiver to receive the broadcast signals;

a demodulator to demodulate the received broadcast signals by an Orthogonal Frequency Division Multiplexing (OFDM) method;

a frame parser to obtain signal frames from the demodulated broadcast signals, wherein at least one signal frame includes preamble data and data symbols including PLP (Physical Layer Pipe) data corresponding to PLPs, wherein the preamble data carries L1 (Layer 1) signaling information including channel bonding information for the PLP data;

a time deinterleaver to time deinterleave the PLP data;

a demapper to QAM (Quadrature Amplitude Modulation) demap the time deinterleaved PLP data;

a first decoder to decode the demapped PLP data;

a second decoder to decode the preamble data; and

an output processor to process the decoded PLP data.

8. The apparatus of claim **7**, wherein the L1 signaling information includes type information of the PLPs, wherein the type information indicates a type of each PLP.

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